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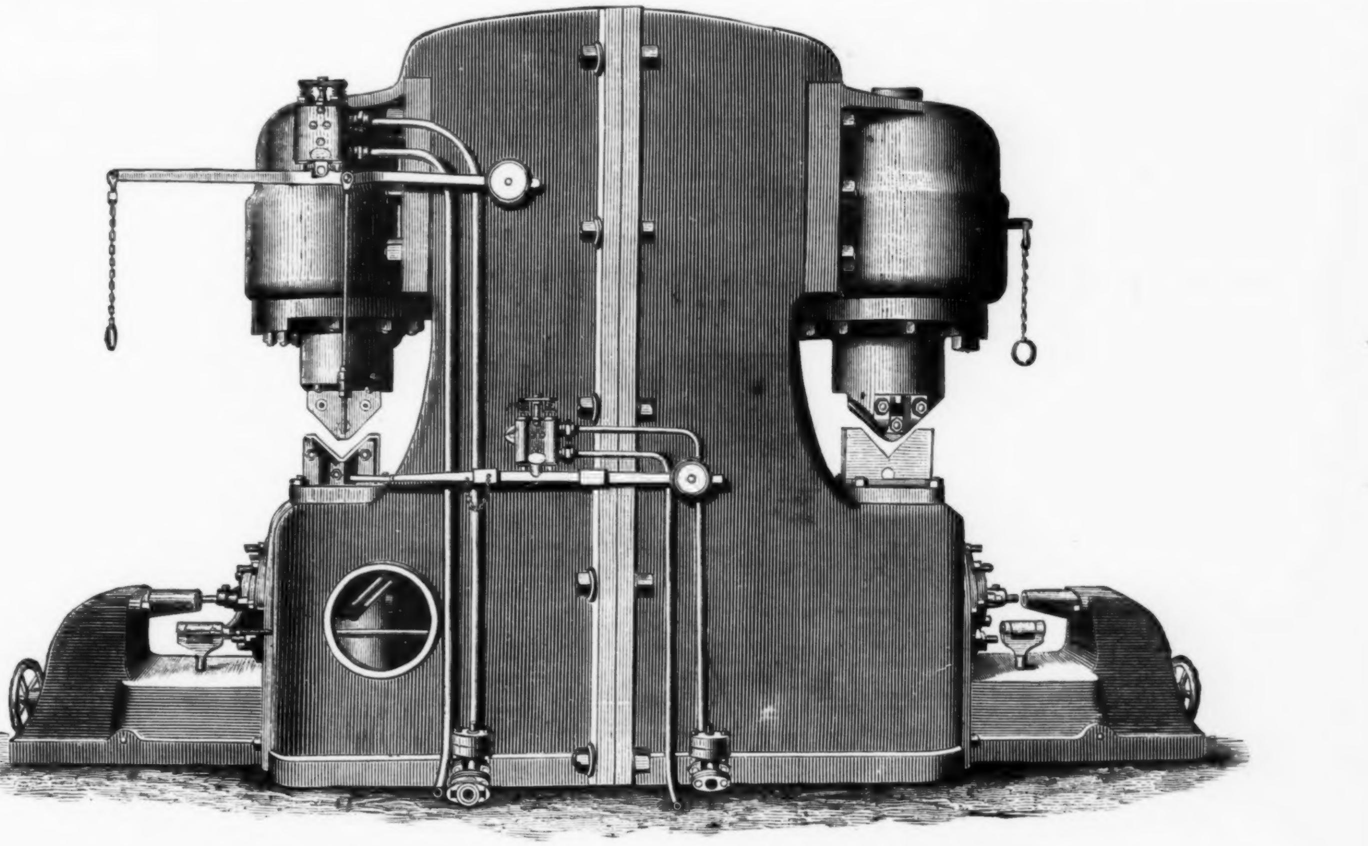
QUADRUPLE HYDRAULIC PUNCHING AND SHEARING MACHINE.

PART of the hydraulic machinery now being erected for the French Government at Toulon by Mr. Henry Chapman, of Paris. The machine here illustrated is capable of shearing on the one side angle bars 6½ inches × 6½ inches × ⅝ inch, and punching 1½ inch holes in same, and on the other side angle bars 5½ inches × 5½ inches × ½ inch, and punching holes 1 inch diameter in same. Our engraving shows the general arrangements so clearly that any detailed description is unnecessary; suffice it to say, that the machine weighs about 28 tons, and that it can with perfect ease make from 15 to 20 cuts per minute. Not only is every cylinder independent of the others, so that a breakdown in the one does not interfere in any way with the other three, but the machine can, if desired, be divided into four machines, each complete in itself, and placed where wanted. There is no gearing whatever, and no shafting or overhead straps, the pipes being led along the floor. Two powerful cranes not shown are placed on the top of the casting, to handle the heavy sections of iron cut by the machine.

It is unnecessary here to refer to the advantages which Mr. Tweddell claims for his system, and which we have frequently had occasion to comment favorably upon; the adoption of it on so large a scale by the French Government, after a very close investigation, is a strong argument in its favor. As a specimen of workmanship the machine reflects great credit on the manufacturers, the castings not being heavy, and having to stand in the cylinders a test pressure of 1½ tons per square inch, rendering very great care necessary to insure, not only strength, but a neat appearance when finished.—*Engineer.*



NEW HYDRAULIC PUNCHING AND SHEARING MACHINE.

INFLUENCE OF FORM ON THE MAGNETISM OF SOFT IRON CYLINDERS.

THOUGH the magnetism of soft iron is a subject that has been largely investigated, it has not been sufficiently recognized that the various experimental researches upon it, not having, for the most part, been made in a homogeneous magnetic field, are not directly comparable with one another, and so the most of the laws laid down are valid only for the special arrangements of a particular experiment. Further—and this objection proves to be a most important one—the researches hitherto have not been sufficiently comprehensive, and, more especially, they have not been made with iron masses whose dimensions varied within wide limits. Lastly, the remanent magnetism of soft iron has been little examined, owing to the small so-called coercive force generally attributed to this material. These reasons recently induced M. Christoph Ruths to make a thorough investigation of the magnetism produced in soft iron cylinders of the most various dimensions, by increasing magnetizing force in a homogeneous field, and of the magnetism which remained after the removal of the induction. The results have been published in a monograph by the author, which has recently appeared in Dortmund. The following is an abstract of M. Ruths' valuable paper: As material for the iron cylinder to be magnetized, commercial iron wire was taken, obtained from the same manufactory. Seven kinds, of different thickness, were examined, their radii being, on an average, 2·54, 1·67, 1·39, 0·81, 0·62, 0·44, and 0·31 mm. Of these different thicknesses pieces were prepared, whose lengths in millimeters were 200, 190, 180, 170, 160, 150, 140, 120, 100, 80, 60, and 40; further iron cylinders were procured, the radii of which were 6·5, 5·65, 4·87, 4·02, 3·65, and 2·75 mm. Altogether seventy bars were examined, whose dimensions varied from nearly cubical form to the most extended forms. Their specific gravity was on an average 7·794. All the cylinders were, before experiment, annealed three times. To produce the induction three separate iron spirals were used, the dimensions of which were so large that for most of the rods a perfectly homogeneous field might be assumed. The iron bars were held by cork in the middle of the spirals, and currents of 1 to 8 Bunsen elements were employed. The intensity of the inducing current was determined with a tangent compass; the magnetic moment with a Wiedmann mirror compass. The bars above referred to were nearly all examined with all three spirals, and on an average, in each series of experiments, there were ten separate experiments. For the special arrangement of the experiments, and the order of operations, the precautions taken, and the mode of calculating the various values, we must refer to the original; merely remarking, that all the results of experiment, the magnetizing forces as well as the magnetic moments, are expressed as multiples of the horizontal components of the terrestrial magnetic force, which is assumed to alter but little in the course of the researches. We can only here give the principal results of the experiments. If we denote as induced magnetism the whole magnetism manifested internally by a bar during the action of a magnetizing force, the experiments first show that the moment induced by any magnetizing force in the unit of weight is a constant function of the dimension-relation a (a = relation of length to thickness), and that to equal magnetism of unit weight of different bars magnetizing forces correspond, which are likewise a constant function of a. In bars of the same dimension-relations, equal magnetisms of unit weight always correspond to equal magnetizing forces. If we make the curve of magnetization of soft iron according to the values obtained, we find that for the beginning the quotient of entire magnetism and the magnetizing force does not begin with o, but with a determinate value which increases with the dimension-relation a; the value of this quotient then increases to a maximum, and the increase is completed the sooner, the greater the dimension-relation of the bar. The occurrence of the turning point also depends on a, and the magnetizing force with which this turning point, *i.e.*, the maximum of the quotient, occurs, is a constant function of the dimension-relation. After reaching the turning point the curve of magnetization goes at first with a strong, then with a very slight, concavity to a maximum value. Whether the latter occurs with a finite, or only an infinitely great magnetizing force, must be experimentally determined from further experiments. A study of the question whether and within what limit the induced magnetism may be put proportional to the magnetizing force, leads to the result that for bars whose dimension-relation a is very small—say under 12—the quotient of magnetism by magnetizing force is approximately constant. It is only for bars of a larger a, that Wiedemann's assertion holds good, that the magnetic movements increase more quickly than the intensities of the currents. M. Ruths next compared the foregoing results of experiments with the various theoretically established formulæ for the relation of the induced magnetism to the magnetizing current, and found that not one of them corresponds to the ascertained relations. Nor did a simple relation of the induced magnetism to the dimensions of the bar (whether thickness, length, or volume), appear from the observations. Specially interesting are the facts established by M. Ruths with regard to the remanent magnetizing of soft iron after sudden interruption of a current repeatedly sent in the same direction. From the remanent magnetic moment of a bar, a function of the previously acting magnetizing force, a curve of magnetization was constructed, and such curves were obtained for 56 bars, the dimension relation a of which varied between 20 and 300. All these curves show a constant course throughout. The remanent moments reached, in some bars, values which exceeded ⅓ of the induced magnetism; and the relation of the remanent to the induced magnetism was greater, the greater the dimension-relation, or the longer the bar. The discussion of the tabulated values of the remanent magnetism shows that this, with very small magnetizing forces, is either *nil*, or has only an imperceptible value. With a certain magnetizing force, however, which, for the bars examined, varied between 3 and 10, a marked amount of remanent magnetism occurred. After reaching this perceptible value, the remanent moments increase very quickly, and in a greater ratio than the magnetizing force, and the induced moment. The curve of magnetization soon reaches a turning point at which the remanent moment is about ½ of the maximum; this turning point occurs approximately with the same magnetizing force. In the further course of the curve, the relation of the remanent moment to the magnetizing force reaches a maximum, and the remanent moment then approaches a maximum quickly, and much sooner than the induced magnetism. When this has been reached, there is in general no decrease from it. On the other hand, proportionality was in no case met with between remanent magnetism and magnetizing force. A comparison of the maximum values, according to the dimension-

relations, shows throughout a decrease of them, with decrease of the length of equally thick bars; with reference to moments of bars of equal length, but different thickness, there seem to be the most manifold varieties. If, however, the maximum remanent moments be ranged according to the dimension-relation a, a conformity to law at once appears. The maximum of remanent magnetism referred to unit weight of a bar is a constant function of the dimension-relation a. This function, with a = about 7, cuts the axis of abscissæ; below this value it is negative, above it positive. Above $a = 7$ it rises very quickly, turning its convex side to the axis of abscissæ; this relation then reaches a maximum, and the curve rises in less degree than before. The remanent magnetisms are therefore greater, the longer the bars. The remanent moments in unit weight reached the remarkable value 727, a value which is over 80 per cent. of the corresponding induced moment, and far exceeds all hitherto observed moments. We must not here dwell on the relation of the remanent magnetism to the lengths of the bars, their thickness, and the magnetizing force, which are fully discussed by M. Ruths. It may merely be observed that the remanent magnetisms here referred to had quite a stationary character. In long bars, 24 hours after induction the loss of force was only about 3 to 4 per cent., which may very well have been caused by shaking in the process of removing from the spiral. A general survey of the peculiarities of induced magnetism and remanent magnetism, as above indicated, leads to the conclusion that "in direct opposition to the prevailing opinion, according to which the laws of induced magnetism are considered directly transferable to remanent magnetism, the remanent magnetism of soft iron shows a very different behavior from the induced magnetism." This conclusion places remanent magnetism in quite a new light. M. Ruths is going to make it the starting point of new investigations. In an appendix the author considers the magnetism of steel, and shows that similarly, not only the induced, but also the permanent, magnetism of steel depends on the dimensions of the bar.

AMERICAN IRON AND STEEL WORKS.

By A. L. Holley and Lenox Smith.

The Black Diamond Steel Works at Pittsburgh, Pennsylvania, belonging to Park, Brother & Company, although not extensive in comparison with some of the similar establishments abroad, is one of the most important crucible steel works in the United States, and is well planned both as regards simplicity and convenience of general arrangement. The iron refinery, which includes the puddling forge, together with its auxiliary buildings, coal bunks, etc., is 336 feet by 124 feet in extent. The puddled blooms are hammered under a 3 ton double acting steam hammer, the steam for which is obtained from boilers over the puddling furnaces. The hammered blooms, after passing over the scales located between the offices, are reheated and rolled into bars in the rolling mills, and are then converted. The converting house is 60 feet by 186 feet in extent, and contains six cementing furnaces of 30 tons capacity each. Adjacent to the converting house, the cemented iron is arranged according to different degrees of temper in bins after being broken up and selected ready for melting. The melting house is 450 feet in length, containing 72 coke melting holes, two 24 pot Siemens gas melting furnaces, one 30 pot gas melting furnace, and 8 gas producers, giving a total melting capacity of 30 tons daily.

The rolling machinery is all under one roof; there are four engines supplied with steam from a battery of six double flued boilers. This building is 401 feet by 217 feet, with an addition of 65 feet by 116 feet in area, and in it is rolled all iron to be cemented, and also tool, spring, machinery steel, etc., from the smallest to the heaviest size, besides plate and sheet steel. This department contains six trains of rolls, the smallest being 8 inches and the largest 30 inches. The 8 inch and 10 inch trains are driven by a vertical engine with 23 inch cylinder and 30 inch stroke, giving 150 horse power. By a simple and rapid arrangement the speed of these trains can be varied from 80 to 290 revolutions per minute, according to the work on which they are running. The 12 inch and 16 inch trains are driven by a vertical engine; the cylinder is 30 inches, and the stroke 30 inches, giving 250 horse power. The largest engine is also vertical, having a cylinder 42 inches in diameter, and stroke 42 inches, the horse power being 600. It drives two sheet and plate trains, the large plate train consisting of one pair of rolls 30 inches in diameter, two pair 24 inches, and one pair 26 inches in diameter. The fourth engine is horizontal with 12 inch cylinder and 24 inch stroke, giving 50 horse power; it drives the eighteen shears used in trimming sheets, slabs, plates, etc.

The forge and hammer shop, is 96 feet by 125 feet, and contains ten steam hammers, the smallest being 4 cwt. and the largest 60 cwt.; also five heavy helve hammers driven by a vertical 50 horse power engine with 14 inch cylinder. This building also contains twenty furnaces for reheating ingots. The smaller forge and hammer shop is 60 feet by 132 feet, and contains four double acting 12 cwt. hammers, eight reheating furnaces, and also a battery of eight double flued boilers, which supply steam to the fourteen steam hammers, and to the engines which drive the five heavy helve hammers, the machine shop, roll turning shop, and fan blowers. In these two forges all shapes of tool steel bars are produced from ¼ inch up to 8 inches in diameter, and also railway and other forgings of every description.

To facilitate the transportation of ingots from the melting shop, and also of the finished product from the mills and forges to the inspecting house, a tramway is constructed traversing the yards throughout. The crucible house has a total storage capacity of 2,000 crucibles. The machine shop is 50 feet by 52 feet, and is well supplied with lathes, planers, drill presses, slotting machines, bolt cutters, etc.

The roll turning shop is 24 feet by 60 feet in extent, and has complete appliances. A system of steam pipes is arranged throughout the entire establishment in such a manner that steam can be used from both batteries of boilers, jointly or separately, thus allowing one set to be cleaned while the other is running, and also allowing the running of such portions of the works as may be most needed when steam can be had from one battery of boilers only. The works are traversed by an underground system of galleries or vaults, aggregating 1,301 feet in length, through which the ashes and cinder are discharged into the river.

The capacity of these works is fully 10,000 tons per annum, the product comprising every kind and form of crucible steel which the trade requires.

The exhibit of Messrs. Park, Brother & Co. at Philadelphia was twofold, one portion being in the Government Building, and a similar though less extensive display in the Main Building. The exhibit in the Government Building was surrounded by a homogeneous steel railing twisted cold, the supports being bars of different sizes, with bases, caps, and nuts of homogeneous steel. The display consisted of Lake Superior, Lake Champlain, and Missouri ores, raw, crushed, washed, and calcined; also loops, billets, pig, puddle balls, blooms, rolled iron, blister bar, and ingots, some of which were fractured, besides steel bars, sheets, and plates. The central feature of the exhibit was a very graceful shaft composed of round machinery and "spindle" steel surmounted with an ornamental cap and a pennant or guidon of steel. The height of the shaft, including the base, was 16 feet, the base being 5 feet in height, and composed of square blocks and bars of die steel, the corner columns being octagonal die steel and railway axles. The panels of the base were formed of square, flat, round, "pivot," and "eye pin" shapes and sheet steel, both plain and highly polished. Some very handsome specimens of boiler and fire-box plate were also shown, bent cold in some cases, the most striking test being a plate 20 feet long, 32 inches wide, and ¼ inch thick, tightly coiled in a roll of the same material. A number of large fractured bars, reaper knives showing the required tests, oil well forgings, bits, reamers, railway frog points and plates, and agricultural steel were also shown, together with a variety of solid steel edge tools with the eyes punched, and also files, cutlery, taps, dies, etc. Several beautifully finished axes, picks, and other tools were also exhibited still attached to the ingots from which they were respectively forged.

The exhibit in the Main Building also consisted of a display of raw materials and various finished products, the specimens of difficult flanging of plates in various shapes being especially remarkable. The most complex flanging was in the form of a large star having a diamond shaped opening in the center, also flanged. An ingot was shown which was "cogged," welded, and finished in different sizes, decreasing towards the end, illustrating the successive stages of manufacture from the ingot to the bar. Many tested samples were included in the display, and a conspicuous feature was a large homogeneous plate 168 inches long and 72 inches wide, which was beautifully finished. As regards the quality of material and workmanship, this comprehensive and tastefully designed exhibit was certainly most conclusive, the high finish of the products, their great variety of grades, and numerous tests, all contributing to render it singularly interesting and instructive. The exhibit contained every variety of crucible steel demanded by the trade, and each grade showed especial adaptability to the purpose for which it was intended.—*Engineering.*

ANCIENT RIVER CHANNELS.

We give the result of an interview with Mr. H. S. Jacobs, who has lately made an extended trip in the gravel mining regions of California. Regarding the manner in which the channels of the buried rivers were formed, as well as the character of the streams themselves, and the agencies most active in filling them up, Mr. Jacobs entertains opinions not altogether in accordance with the more commonly accepted theories. The channels of these old rivers, he believes, were eroded by fluviatile, and not by glacial, action. These rivers, though of great magnitude and running swiftly, were not remarkable for their length. They had their sources, like the modern river system, in the valley of the Sacramento, and did not head in the far north, traversing some thousands of miles in their course, as some writers on this subject hold; their theory being that the enormous boulders formed in the channels of these buried rivers could have been brought down only by a vast, swift rushing volume of water, and that they must have come a great distance to have been rounded and polished as we now find them. In the great width of the water-worn bedrock, as disclosed by hydraulic and drift operations, we find, as these theorists alleged, further evidence of the immensity of these pliocene rivers. But as this might have been produced by these streams shifting their channels, it does not conclusively prove for them an extraordinary width.

HOW THE BOULDERS AND GRAVEL WERE PRODUCED.

This entire country was once submerged by the sea, as is shown by the marine fossils scattered over it. The volcanic action that produced the Sierra Nevada gradually raised the whole country above the surface of the ocean, after which the ancient rivers began to form, wearing out in course of time their present channels. After these were eroded, volcanic and other dynamic movements ensued, crushing the quartz veins that thickly ribbed the Sierra to its top and grinding them into fragments, accumulated along the mountain sides great masses of this gold-bearing detritus. Some of these convulsions, occurring periodically and with great violence, so tilted up the westerly slope of the mountains that immense quantities of these boulders and this auriferous gravel, rendered smooth and sound by previous commotions, were suddenly swept into the old river channels running not far below, filling them up and forcing the water further over towards the west, where it formed for itself a new channel. Through the repetition of this process the several old river beds, forming an irregular and somewhat complicated system, as we now find them, were produced.

THE OUTPOURINGS OF THE VOLCANOES.

In the meantime, the volcanoes along the crest of the Sierra for a distance of several hundred miles, belched forth at intervals showers of ashes, which, falling into the torrents along the mountain sides, were carried down and deposited in the channels of the rivers, already partially filled up with gravel, clay and boulders, forming with the alumina and magnesia, brought down the massess of pipe clay with which the auriferous material is interstratified or overlaid. Following these outpourings of ashes and this flow of other matter, came floods of lava and conglomerate, which, running down the mountain sides, covered up, above a certain line of elevation, both the pipe clay and the entire country, in many places to a great depth.

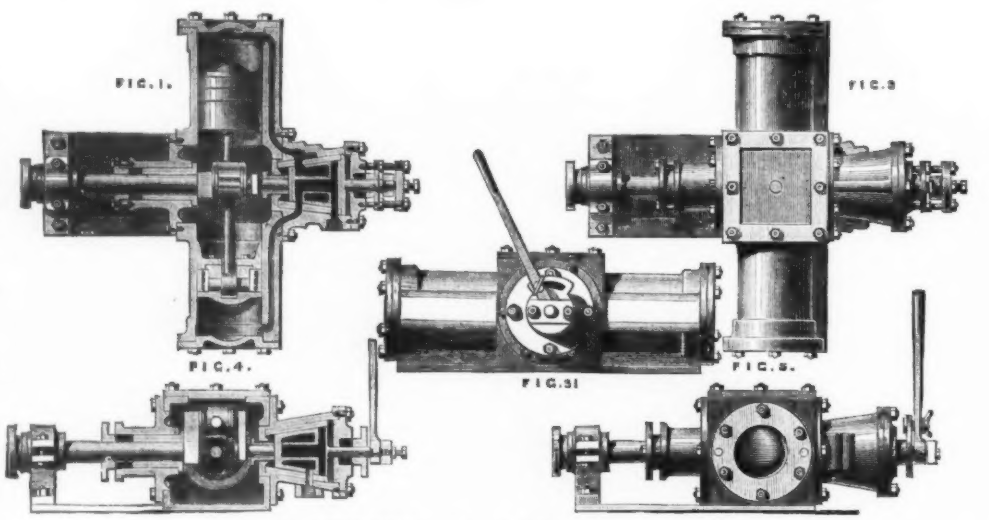
OTHER EXAMPLES.

The alumina and magnesia, being the lightest materials in the interior of the earth, would naturally be on top of the boiling mass that filled the volcanic craters, and, hence, the first to flow out. Of this fact, Mr. Jacobs, during a visit to the Sandwich Islands, learned from an eye-witness a striking confirmation, which occurred during an eruption of Mauna Loa, in the Island of Hawaii, where a stream of this material, forcing an orifice through the lip of the crater, shot out like the arch of a rainbow, and passing over a number of persons without injuring them, fell upon others further down the mountain side with fatal effect. Mr. Jacobs has examined the gold-bearing gravel deposits of Australia and believes them to be coincident in chronology, and to have been formed by the same agencies as were those of California.—*Min. and Sci. Press.*

THE WIGZELL & HALSEY MACHINE.

We give above engravings of a form of single-acting engine by Wigzell & Halsey, of London. It consists of two single-acting cylinders placed opposite each other with the crank shaft between them, each cylinder being fitted with a deep piston from which a connecting rod is led direct to the crank. The connecting rods are, of course, always in compression. The pistons, we may mention, are fitted with Mr. Wigzell's packing, in which a spiral steel spring is employed to set out the cast iron packing rings, the construction of the spring being such that it not only tends to spread the rings radially, but also forces them against the faces of the piston.

The distribution of the steam is effected by a conical rotating valve, the spindle of which carries a crank arm which takes hold of the crank pin of the crank shaft, as shown in Fig. 4. As will be seen from Figs. 1 and 4, the conical valve revolves within a conical seating, which can itself be turned through a small arc by the hand lever shown. The effect of so turning the valve seat is to transpose the communications with the steam and exhaust openings, and so reverse the engine. The particular engine shown in our engravings is adapted for use in a steam launch, but Messrs. Wigzell & Halsey are constructing the engines for a variety of purposes, some of the engines being made with three cylinders. —*Engineering.*



THE WIGZELL & HALSEY ENGINE.

AMERICAN AXES IN ENGLAND.

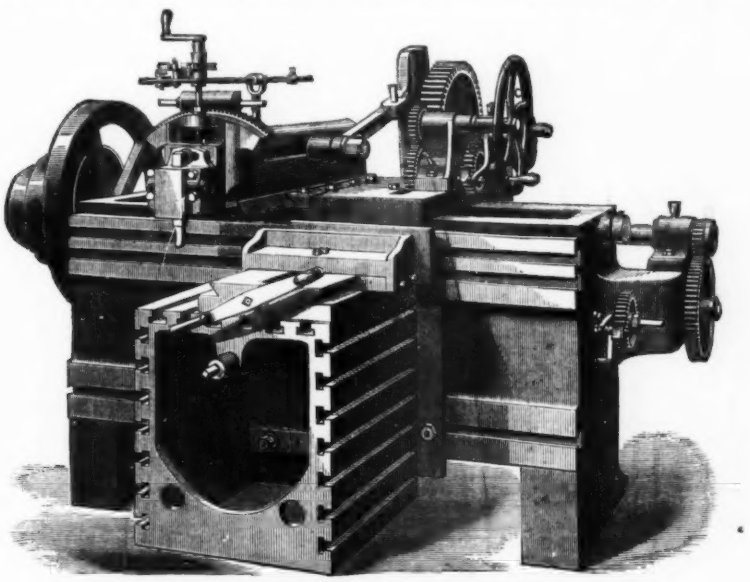
A writer in the *British Trade Journal* says: "I venture to bring to your notice a circumstance which would appear to be the commencement of a very sharp contest with our American cousins for the supply of a certain class of goods in the home market. Having occasion to buy an ax in one of our best retail shops in London, I was strongly recommended to invest in an implement bearing the brand "Collins & Co., Hartford," as being of better temper, more durable, and of better shape than an English ax. On my expressing surprise that our edge tool manufacturers could not compete with Americans in their own market, I was informed that the English makers declined to alter either their style or their shape. I was aware that the hickory handles were always imported from the States, and, as I understood, headed, and sent back again, but it appears that we are not only beaten in the States, but also on our own ground, which seems incomprehensible. Inventions for saving labor, of course, find their way to England, and being protected by patents, make their own reputation if appreciated by the public, but the British workman is scarcely alive to his own interest if, owing to the high price of labor and constant strikes, he renders it impossible for our manufacturers to turn out such a simple article as an ax at a price, and of such a quality, as would discourage the importation of foreign goods.

"Probably my ax is only one of many American tools used in England, and it would seem that our American friends are beginning to attack the colonial markets, and will

doubtless discern the advantage of making their wares known through the medium of your valuable journal. The result is to be deplored, but competition is so keen that we must all deal upon the most advantageous terms."

COLLIER'S SHAPING MACHINE.

OUR engraving illustrates a very effective form of shaping machine as made by W. Collier & Co., Manchester, Eng. Not only does each cutting head carry its own traversing motion, but any number of cutting heads can be placed on one bed, and all traversed independently by one screw. As shown in the annexed engraving, the screw in the bed is stationary, and the nut upon it is securely attached to a



COLLIER & CO.'S SHAPING MACHINE.

pinion into which the wheel A gears. This wheel A is keyed on a stud at the other end of which the wheel B is secured, and it will be seen that this wheel is acted upon by a ratchet and pawl worked from a slotted crank disk on the main shaft of the machine; thus, at each stroke of the machine, the nut wheel, being turned upon the stationary screw, moves the cutting head, and by reversing the catch it will feed in either direction.

To traverse the head quickly by hand, the handwheel C is geared up to the nut on the bed screw as shown, and by throwing out the catch and turning the handwheel the nut is caused to revolve on the stationary screw, and thus travel the head quickly. The gearing at the end of the bed is for the self-acting circular motion.

Some hundreds of these machines of all sizes, some with beds 30 feet long and three or four cutting heads on, have been made, and this feed motion has always answered admirably. A stop motion to each cutting head, to throw it out of gear instantly, is also applied.

TAYLOR'S PLATE PICKLING MACHINES.

Messrs. TAYLOR & Co., Briton Ferry, Engineers.

WE illustrate above an improved apparatus for cleansing the plates or sheets of iron to be coated with tin or terne metal—the latter being a mixture of tin and lead—and which process is commonly called pickling.

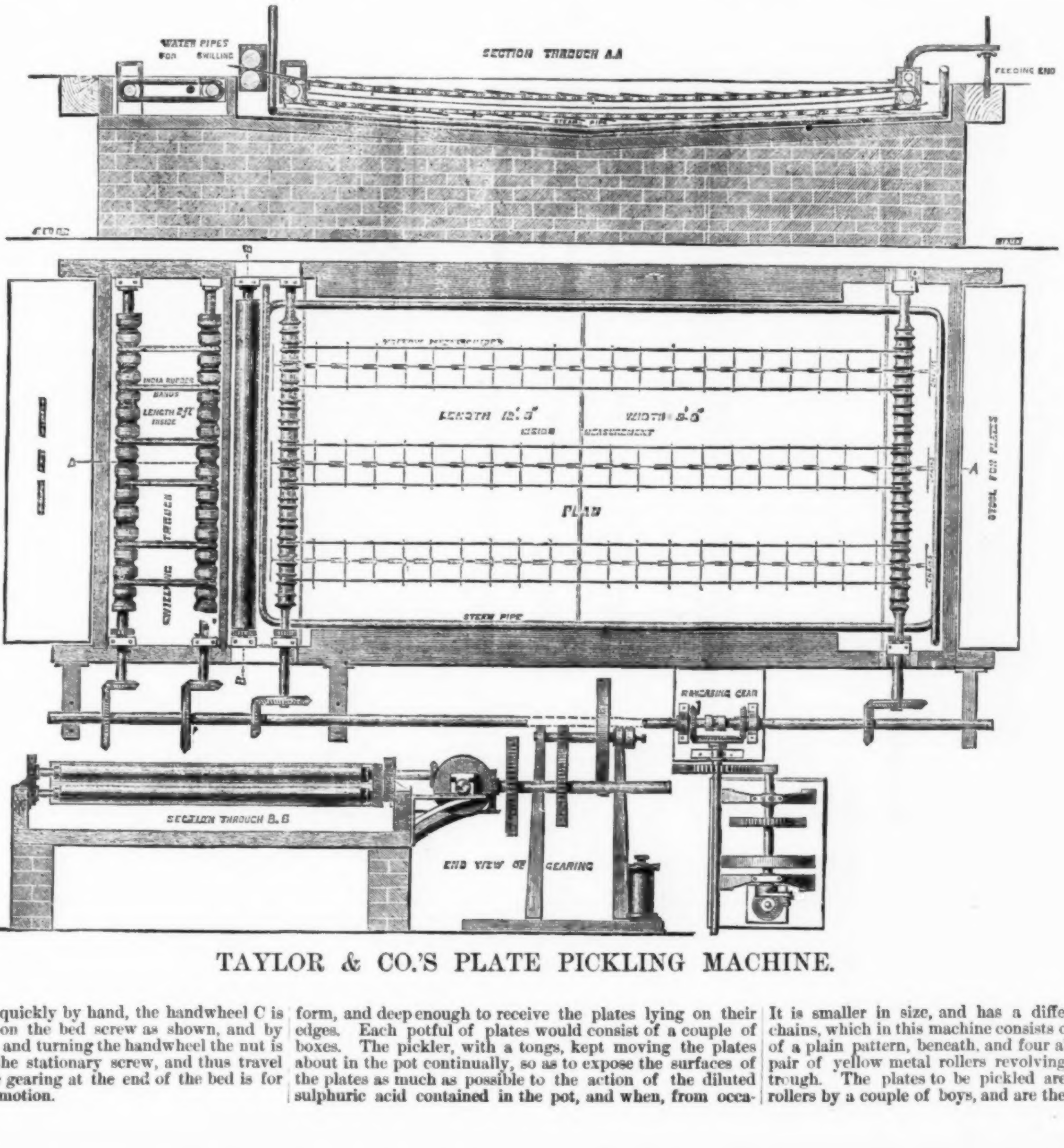
Before the iron sheets can take their coating of tin effectually, all impurities, such as oxide, etc., must be removed from their surfaces, and for that purpose they are generally pickled in a bath consisting of a mixture of sulphuric acid and water. By the old process of pickling, previous to the introduction of these patent machines, sawdust was introduced between the sheets before they were immersed in a pot or trough, which was usually made of lead, of rectangular form, and deep enough to receive the plates lying on their edges. Each potful of plates would consist of a couple of boxes. The pickler, with a tongs, kept moving the plates about in the pot continually, so as to expose the surfaces of the plates as much as possible to the action of the diluted sulphuric acid contained in the pot, and when, from occasional examination, he found the plates had cleared sufficiently—which would be in from four to eight minutes after being put in the acid—they were raised from the pickling pot, and handed over to girls called swillers, who washed the plates in troughs containing constantly running clear water, great care being required that the sawdust which adhered to the plates was brushed off, otherwise black spots, causing wasters, would result when the plates were tinned. The sawdust was simply used for the separation of the plates while in the acid, and its absorption of a considerable portion of the acid made its use very objectionable.

This process was necessarily unhealthy to the pickler, who, by being constantly at work over the pot, inhaled the deleterious fumes of the acid. Messrs. Taylor & Co., of Briton Ferry, Glamorganshire, have invented and introduced machines for pickling and swilling by mechanical means, which, besides doing away entirely with the unhealthy nuisance of the old process, effect, we are informed, a saving of 50 per cent. in the cost of pickling.

We give illustrations of one of Messrs. Taylor & Co.'s black pickling and swilling machines—which is driven by a vertical 1-horse power engine—capable of pickling and swilling from 200 to 250 boxes of plates per day of 10 hours. The construction of the machine can be readily understood from the illustrations. The trough, which is of wood lined with strong sheet lead, is about 12 ft. long by about 6 ft. wide, and tapering from 8 in. depth at the ends to 12 in. depth in the center, and has three yellow metal endless chains running on rollers of the same material, which revolve at each end of the trough. The chains are so constructed that when three boys, who each feed one chain of the machine, places the plates singly upon them, each alternate link of the chains, being made with a T-head, nips each plate separately and firmly in its place, and carries it through the trough of acid, the time occupied in passing through the machine being from 2 to 3 minutes. These chains travel over yellow metal guides placed longitudinally in the trough. When the plates have traversed the whole length of the trough a pair of rollers receives them and passes them on to endless india rubber bands traveling on a pair of wooden rollers. By means of two pipes perforated with holes, one above the india rubber bands and the other below, constant jets of water strike against both sides of the plates as they are carried along; by this means they are effectually swilled and thoroughly cleansed from the effects of the acid. The plates are received by three girls, who examine each one carefully, and any not having been thoroughly cleared from the oxide are passed through the machine again.

The plates have now to undergo the process of annealing by being placed in air-tight iron boxes, and exposed to an intense heat in a furnace for 6 to 8 hours, which softens them. They are then passed through several pairs of highly-polished rollers to flatten them, and give them a smooth, glossy surface; this operation is called cold rolling. By being cold rolled the plates get hard again, and require to be once more annealed and softened, after which they are white pickled, which is the last process they undergo previous to their receiving their coating of tin or terne.

The white pickling and swilling machine of Messrs. Taylor & Co. differs in some respects from the black machine. It is smaller in size, and has a different arrangement of chains, which in this machine consists of nine endless chains, of a plain pattern, beneath, and four above, working upon a pair of yellow metal rollers revolving at each end of the trough. The plates to be pickled are placed between the rollers by a couple of boys, and are then carried through the



TAYLOR & CO.'S PLATE PICKLING MACHINE.

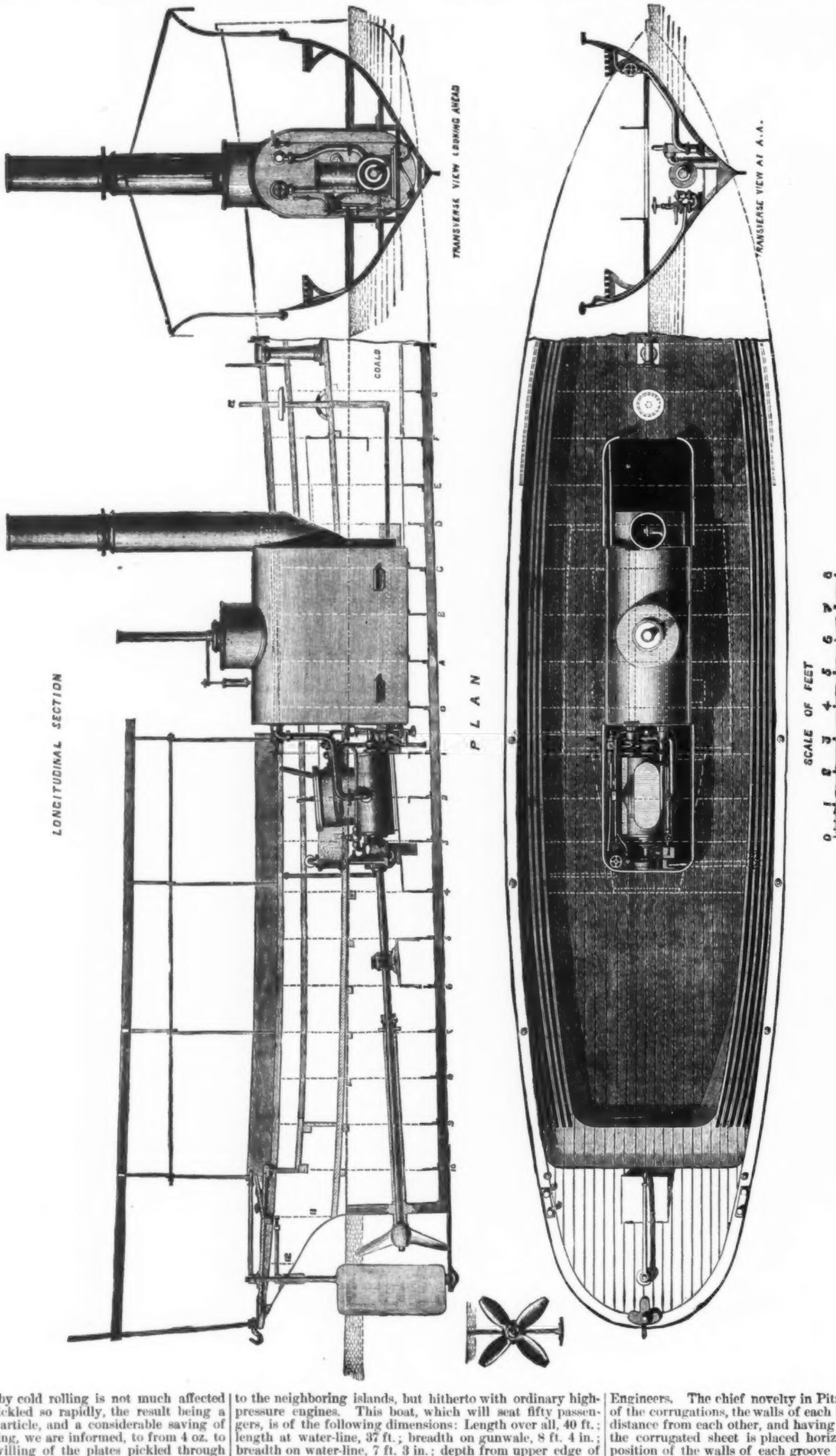
acid by the bottom chains; the top chains are for the purpose of keeping the plates from floating in the acid. The plates are not kept distinctly separate in passing through the white machine, as they are in the black, but are passed in as fast as the boys can feed them. The vibration of the chains acts as a constant wave, penetrating and acting effectively upon the entire surfaces of the plates.

By the old method of white pickling, the process occupied several minutes, but in Messrs. Taylor's white machines the plates are pickled in one minute. The polish put upon the surfaces of the plates by cold rolling is not much affected when the plates are pickled so rapidly, the result being a better-looking finished article, and a considerable saving of tin is effected, amounting, we are informed, to from 4 oz. to 8 oz. per box. The swilling of the plates pickled through the white machine is effected as already described.

These machines are now, we understand, being largely adopted in the various tin plate works throughout South Wales, and those manufacturers who have erected them speak highly of the advantages they derive from their use.—*Engineer.*

RUSSIAN STEAM LAUNCH.

WE illustrate a new steam launch, built by Messrs. William Crichton & Co., of Abo, for river traffic. The novelty in this launch consists in the introduction of one of Willan's patent three-cylinder engines, which has been supplied by Messrs. Tangye, of Birmingham. The engraving also shows the style of launch in use on the Neva and in Sweden. These launches are being successfully introduced on the Neva, and several of them are running from St. Petersburg to the neighboring islands, but hitherto with ordinary high-pressure engines. This boat, which will seat fifty passengers, is of the following dimensions: Length over all, 40 ft.; length at water-line, 37 ft.; breadth on gunwale, 8 ft. 4 in.; breadth on water-line, 7 ft. 3 in.; depth from upper edge of keel to gunwale, 4 ft. 7½ in.; draught, 3 ft. 3 in.; draught forward, 2 ft. 3 in.; displacement, 224 cubic feet; nominal horse-power, 6; indicated horse-power, 36; diameter of cylinders, 6 in.; length of stroke, 6 in.; number of revolutions per minute, 300; speed of boat, about 10 knots per hour. She is fitted with a Giffard injector for feeding the boiler, and a Friedmann ejector for discharging any water that may come into the boat. The boat can be managed by a man and a lad, as the engine is under the control of the helmsman through the lever *a*. She is built of Swedish iron, supplied from the Degerfors Works, and is a handsome model.—*Engineer.*



NEW RUSSIAN STEAM LAUNCH.

SPECIMENS of a new style of corrugated iron for building purposes have been submitted by an Austrian engineer named Pitze to the Austrian Association of Architects and Engineers. The chief novelty in Pitze's patent is the shape of the corrugations, the walls of each being higher than their distance from each other, and having a vertical profile when the corrugated sheet is placed horizontally. This vertical position of the walls of each groove enables the corrugated sheet to bear its maximum load, and thus to fit it for general use in construction.

MCAFEE, SPIERS & Co., San Francisco, boiler makers, employ about 130 skilled workmen, and make boilers for the vessels launched in California.

THE BURLEIGH TUNNEL, GEORGETOWN, COLORADO.

DIRECTLY under the shadow of the great cliff which rises on the north side of Silver Plume Creek, about a quarter of a mile below the town of Brownville, is the mouth of the Burleigh tunnel, an enterprise which, we believe, was inaugurated in 1869 or thereabouts, and, after being driven into Sherman Mountain for 1,300 feet, was temporarily abandoned by reason of the fact that the veins intersected were all carriers of too low a grade of mineral to be mined with profit. Great hopes were entertained of the ore bodies thought to be in the line of the tunnel which crossed the Bush, Mendota, Cashier, Phœnix, Coldstream, Virgin, and numerous other veins, and much disappointment was felt when work was stopped, because the impression was conveyed to all who passed by its mouth and saw its smokeless stack that the veins of Sherman Mountain were barren and worthless in depth.

For many months no work was done, but at last the owner resolved to push it ahead once more. A force of men was put on, and, discarding the heavy drill carriage, a reduced bore was decided upon, and 600 feet more was driven, making its length between 1,890 and 1,900 feet. There being no important developments, work was again discontinued till last summer, when it was decided to push it 600 feet further on, and to prospect what is thought to be the Bush lode, which was cut 900 feet from the mouth. The work has since gone steadily ahead, until at present the header is 2,200 feet from the mouth, the last 100 feet being driven almost wholly in ledge matter carrying numerous streaks of ore and showing fair assays. No stop, we believe, is to be made until a length of 2,400 feet is gained, when it is greatly to be hoped enough ore-bearing veins will be crossed to insure the extraction of ore sufficient to at least pay the expenses of continued exploration.

The section of Sherman Mountain undercut by this tunnel shows many veins on the surface, but, with the exception of the Coldstream, Phœnix, Cashier, and Mendota, but little development has been done upon them. It has been thought by some that a low grade belt of lodes existed on this part of the mountain, but wherever extensive work has been done above this idea is positively disproven. The tunnel, as driven so far, indicates that the veins continue downward unmistakably, and had those already cut been explored east and west, as has the New Era or Bush, an abundance of ore would doubtless have been found. We learn it is the intention of the owner hereafter to follow this course. If large bodies of ore are found, the 600 feet of narrow tunneling will be blasted out to full width (8x10), a double track laid, and ample accommodations made at the mouth for sorting, storing, and shipping mineral. It would be a real misfortune to the prosperous district around Georgetown to have another suspension of this important work.

The breast of the tunnel is now about 1,800 feet below the surface. Should the Coldstream preserve the dip it has shown on the surface, it will not be intersected short of 3,100 feet from the mouth, and over 2,000 feet below its outcrop. The utmost confidence may be felt that when that noble vein is reached plenty of ore will be found, and, should the tunnel reach it, Colorado will have the distinction of having the deepest metal mine on the continent next to the Comstock. The Cashier has already been cut beyond a doubt, but where the tunnel crosses it the vein is split up into a number of minor seams, which so far have discouraged exploration. Where opened upon the surface, this lode showed as rich ore as has ever been taken from the mountain, and yielded well until a barren chimney of exceedingly hard rock was encountered, through which the company never penetrated.

Back of the Coldstream lie the Virgin, Epluribus, Quaker, St. Joe, and a host of promising veins. The extensions of the Antelope, Pelican, and Coony City coming in from the east, and of the Brown, Benton, Hercules, and President from the west, must cross the line of the tunnel on or near the crest of the mountain, and it is impossible to believe that large bodies of rich ore do not exist on their course.

From the crest of the mountain down to the level of the tunnel is a distance of not less than 3,000 feet. The opportunity for opening a vast amount of mineral ground known to be rich is not to be excelled in any part of the West. Sutro has had to drive 1,800 feet to reach the nearest ore seam of the Comstock, and does not gain over 2,000 feet in depth, while the Burleigh tunnel will open the entire mineral belt of Sherman, Brown, and Republican Mountains to a depth of 3,000 feet by a tunnel not over 4,500 feet in length. And a careful study of the veins on this range, with their history and production, cannot fail to impress one favorably with the district.—*Engineering and Mining Journal.*

WHITE LEAD.*

THE white lead of commerce is used chiefly for the purpose of manufacturing white paint, and it is essential that this white paint should possess two distinct although compatible properties, viz.: first, the power of covering or laying on to wood, or other substance, in such a way as to cover every atom of the surface painted; and secondly, opacity, or the power of hiding any color, whether paint or other substance, which may have been beneath the paint thus being applied. Nine tenths of the white lead manufactured in England, or indeed on the Continent, is made by what is called the Dutch method—that is, by subjecting metallic lead to the action of the fumes arising from acetic acid, heated in beds of tan or other similar decomposing organic material.

Many of the older textbooks state that the white lead paint of commerce consists of the anhydrous meta-carbonate of lead, but this is practically disproved by the fact that the native white lead ore or cerusite is quite incapable of being ground up with oil to form a paint which shall be of any commercial value whatever. We may, therefore, leave entirely out of the question this native product, and consider only the manufactured article. Now, there are two different ways in which white lead has been manufactured—first, the Dutch process, by which at least nine tenths of the total quantity consumed is made; and secondly, precipitation, by which a small quantity, certainly not so much as one tenth, is made. Quoting from Watts, showing as he doubtless does, an epitome of nearly all the published statements on the subject, we find that when the precipitation process is used, and an excess of carbonate of ammonia is added to a solution of lead, the anhydrous meta-carbonate of lead is precipitated, while, according to Lefort, the hydrated salt, consisting of hydrated metacarbonate of lead, is thrown down; therefore, according to both these views, the precipitation consists of carbonate of lead, anhydrous in the one case, and hydrated in the other case. H. Rose, however, mentions that the precipitate always contains hydrate of lead, and this is the first time that we find any mention of this compound occurring in any white lead, particularly in that obtained by precipitation, but it is clearly to be noted that the proportions which Rose directs for the admixture of the solutions of salts of lead and carbonate of soda are not such as to give an excess of the alkaline base, and he further states that the composition of the precipitate thrown down was six equivalents of carbonate of lead and two equivalents of hydrate of lead + one equivalent of water.

Rose also states that, under some conditions, which he specifically details, another compound may be obtained, consisting of five equivalents of carbonate of lead and two equivalents of hydrate of lead; and, under other conditions, another precipitate may be obtained, consisting of three equivalents of carbonate of lead and two equivalents of hydrate of lead; our experiments lead us to doubt both these results. Watts further goes on to say that "hydrated carbonates of lead are also formed by the direct action of carbonic acid on hydrate of lead, and the compounds thus obtained differ from the precipitated carbonate in being amorphous and perfectly opaque, while the precipitated carbonate is an aggregate of minute, transparent crystalline grains." We differ entirely from both these statements. We do not believe that the direct action of carbonic acid ever produces hydrated carbonate of lead, but, on the contrary, it produces either an admixture or a slight chemical combination of carbonate of lead and hydrate of lead, both of these compounds, however, preserving most of their original chemical properties; and when the carbonate of lead and hydrate of lead are precipitated in the proper manner, they do possess the characters, or, rather, to speak more correctly, the character, of an amorphous and opaque precipitate, and not "an aggregate of minute, transparent crystalline grains."

As the result of the examination of some hundreds of samples of commercial white lead (in all nearly 1,000), we must decidedly express our opinion that the material consists not of a basic carbonate, but of a mixture of a neutral carbonate, with a hydrate, and that the value of the white lead as a paint, whether it be prepared by the Dutch process or by precipitation, depends almost entirely upon the relative proportions of these two different ingredients. To put it in general terms, if lead is either by the dry or wet process converted into a hydrate, it is perfectly true that it will combine with oil, and form a kind of paint or varnish; but this paint or varnish, although it will spread over the surface of the wood or other material to be covered, will not really cover it in such a way and with such a degree of opacity as to hide the natural color of the substance over which it is spread, but, on the contrary, it will appear like a muddy film of varnish or lacquer spread over it; or, taking the other extreme, if the compound, whether formed by the dry or wet process, consists entirely of carbonate of lead, it will form an emulsion with the oil resembling, to some extent, the emulsion which chalk will form with water or with syrup, and although it will possess a certain degree of opacity, it will not cover the wood or other material in such a way as to render it suitable for paint.

We have, therefore, come to the conclusion that the combination or mixture of the two compounds—viz., carbonate and hydrate of lead—is necessary in order to secure a good and serviceable paint—that is, the hydrate of lead must be present in order to enable the mixture to form a paint instead of an emulsion, and the carbonate of lead must be present in order to give covering power.

We will consider this subject in two ways:

1st. We have tested samples of pure carbonate of lead and have made them into paint with the greatest care, and have found that, although it was possible to spread them over the surface of the substance to be painted, and to secure a certain degree of opacity, the paint never really dried or hardened, or became, in the sense a painter would use the term, a full paint—that is to say, the surface of the color over which the paint had been spread was never entirely obscured, and the paint itself, even after some days of drying, was so pulverulent that the ordinary washing was sufficient to remove a large portion of it.

2d. We took commercially pure samples of hydrate of lead, and we ground them up into paint in the ordinary way with linseed oil. These samples when so ground possessed comparatively no covering power—that is, they spread over the substance painted, and formed a varnish-like film, similar to that which would be formed by linseed oil alone, although with a greater degree of opacity, but they did not really cover or hide the color beneath. The chemical combination of the hydrate of lead with the linseed oil sets free a certain amount of heat, sufficient to prove that it is really a chemical combination, and not a mere admixture or emulsion.

Having experimented on these substances—viz., carbonate of lead and hydrate of lead, separately, we experimented upon mixtures of them in various definite proportions. Our experiments here may be numbered by hundreds, and as the result of the whole, we have come to the conclusion that a white lead paint to be efficient, and to possess both the powers of laying on readily and easily, and by its opacity hiding the color beneath, must consist of an admixture of hydrate and carbonate of lead, and that this admixture must be within certain moderate limits in a definite proportion.

The results of the analysis of a very large number of the best brands of commercial white lead show that the percentage of composition found corresponds in most cases with admixtures which are between those limits, and the results of several experiments which we have made prove to us conclusively that this is the true composition of all the best paints. Muter, in his recent book on "Pharmaceutical Chemistry," appears to have practically hit upon the true proportion, which he puts down as three equivalents of carbonate of lead and one equivalent of hydrate of lead, and this corresponds very fairly to the proportion which we find by experience is essential to the formation of good white lead paint.

The facts which we have brought forward seem to us to give ample evidence of the reasons why zinc white, carbonate of magnesia, oxide, and other metallic carbonates and similar substances, have not been able to be used as paints with any degree of success. In the case of the white lead, a positive chemical compound has been formed, and the 75 per cent., or thereabouts, of carbonate of lead present has been dissolved in the chemical compound, and so a paint has been formed which possesses an unquestionable covering power in excess of any other compound known. Until some means can be devised by which oxide of zinc or some other substance can be dissolved in the same way in a chemical compound, so as to form a paint possessing characters somewhat different from those of a mere emulsion, it seems useless to argue that, as regards durability or covering power, they can equal a good well-manufactured sample of white lead, and, still further, while inventors will attempt, in order to increase the yield of paint from a ton of lead, to precipitate the whole of it in the form of carbonate, it is perfectly useless for them to think that that paint can possess a covering power to be compared with that of a genuine article.

* By G. W. Wigner, F.C.S., and R. H. Harland, F.C.S. A paper read before the Society of Public Analysts.

ANNUAL CONVERSAZIONE OF THE ROYAL SOCIETY, LONDON.

THE recent Conversazione of the Royal Society, held at Burlington House, well kept up the high character of the now long series of receptions which the Royal Society has given to its friends. The libraries were literally filled with objects of high scientific interest, and the period of three hours, during which the conversazione lasted, were all too short for the study which they deserved, especially as on such occasions that study must necessarily be so largely interrupted by friendly greetings and conversation.

RADIOMETERS.

Mr. Crookes, F.R.S., occupying his usual corner of the librarian's room, exhibited a splendid collection of radiometers and specimens of his new modification of them, to which he has given the name of the Otheoscope, or propulsion indicator. This instrument differs from the radiometer in the fact that the propelling power is caused by the radiation from blackened stationary disks or vanes fixed at a suitable angle in the neighborhood of the movable fly and within the exhausted envelope. The vanes of the fly, unlike those of the radiometer, are alike on both sides, and the action is precisely like what it would be if the fixed vanes were emitting jets of air and blowing the fly round after the manner either of a Robinson's anemometer or of a smoke-jack. In one of these instruments a four-armed fly with vanes made of mica rendered opaque by roasting is supported on a central pivot like the fly of a radiometer, and within the glass envelope rigidly attached to its sides are three vertical plates of clear mica set at an angle somewhat oblique to the axis. When a candle is approached the molecular disturbance caused by radiation from the oblique plates impinge on the fly and causes it to rotate. In another form a horizontal disk of roasted mica is balanced at its center on a vertical point, and below it is a fixed circle of inclined aluminum vanes of the form of the wheel of a smoke-jack. Upon approaching a candle to this instrument the upper disk moves with great velocity, being driven by the molecular forces caused by radiation acting obliquely to the under surface of the upper disk. Mr. Crookes also showed an instrument which is the converse of the last. In this case the fly is composed of inclined planes of aluminum similar to the fixed vanes in the instrument last described, and below it is fixed a blackened disk of mica. When a source of radiation is approached molecular disturbance takes place due to the radiation from this disk, but as the angles of incidence of the vanes of the fly are inclined to the direction of this molecular disturbance, motion is given to the fly and it rotates at great speed.

Of radiometers Mr. Crookes showed some very interesting specimens, illustrating very remarkably the theory of the radiometer propounded by Dr. Johnstone Stoney. In one example a radiometer of the usual construction, that is to say, having its vanes blackened on one side only, has attached at a short distance from and parallel to the black surface of each vane a large disk of clear mica. When a candle is brought near this radiometer the fly rotates in the abnormal direction, that is to say, with its black surfaces toward the light. This reversal of motion is caused by the reflection, from the clear mica plates, of the molecular disturbance set up by radiation from the black surface. In corroboration of this hypothesis Mr. Crookes showed another instrument in which each vane carried two large disks, one on each side. In this case the molecular disturbance, prevented from being reflected backwards by the second equal-sized disk, can only escape in planes symmetrical with the diameters of the fly, and consequently no motion is produced on the approach of a lamp.

In another new form of experimental radiometer the vanes of the fly are of aluminum, bright on both sides and cup-shaped, similar to those in Dr. Robinson's anemometer, but not so deep. Unlike the anemometer, however, the vanes rotate with the concave surface forward. The radiation from a standard candle placed 3½ in. from this instrument, and falling equally on both convex and concave surfaces, caused the vanes to rotate at a speed of about 18 revolutions per minute. When a screen was placed between the candle and the instrument in such a position as to allow it to shine only on the convex surfaces, the vanes rotated in the same direction as before, but at the reduced speed of 8 revolutions per minute; the screen was then shifted so as to screen the convex surfaces, allowing the radiation to fall only on the concave surface, the rotation continued as before, but at a speed of 8½ revolutions per minute. Mr. Crookes arranged this experiment to show that the repelling influence of radiation on the convex surface is about equal to its attracting influence on the concave surface, and that the double velocity at which the vanes move when both surfaces are exposed to the radiating force is the result of the sum of these two influences. As a sequel to this experiment, Mr. Crookes showed an interesting pair of radiometers similar in construction to that last described, but having in one instrument the concave surface blackened, and in the other the convex. In the former the usual action of radiation is reversed, the bright convex surface being repelled and the black concave surface attracted. In the latter, as might be expected from a consideration of the two experiments, the rotation was in the usual direction and very rapid. In the former the two conditions of the vanes, viz., the curvature of surface and the blackening of one side, are acting against one another, the surface form having the large influence; and in the latter the two conditions by which the vanes are rendered sensitive to the mechanical influence of radiation or acting together, and the speed is consequently increased.

All these instruments are marvels of constructive skill, and have been made by Mr. C. H. Gimingham, who has been associated with Mr. Crookes in this research from the first. Two instruments especially ought to be mentioned as examples of extraordinary delicacy of manipulation. One was an eight armed radiometer rotating at a great velocity upon a horizontal axis, which was supported by two glass cups so delicately adjusted by fusion of their glass supports as to nip the fine needle-points of the horizontal spindle, so as to prevent the latter dropping from its central position, and yet so free from friction that the light of a single candle caused it to "run away." The other instrument consisted, first, of a radiometer having four large rectangular vanes; each of these vanes carried above it a secondary, tiny four-armed radiometer, which consequently had a sort of "lunar" motion, rotating on its own pivot, which in its turn was carried round by the larger radiometer. Above the central fly was again

another radiometer rotating in the opposite direction, and the combination of rapid motions in different directions and at different velocities within a glass bulb about 3 in. in diameter produced a most pleasing and curious effect, and in addition to its marvellous construction it was itself an object of great beauty.

AURORA TUBES.

In the ante-room to the principle library, Mr. Apps showed a very large aurora tube of uranium glass, through which discharges from a large coil were transmitted, producing the beautiful characteristic green fluorescence due to that metal.

NEW HOLTZ ELECTRICAL MACHINE.

In the same room Mr. Ladd exhibited a Holtz electrical machine with four plates, the whole apparatus being enclosed in a glass case, in which the air is artificially dried. By this means the great drawback to the use of the Holtz machine in the damp climate of this country is removed, and the brilliance of its discharges and the length of its sparks on Wednesday night (which was anything but favorable for electrostatic effects), proved the instrument to be independent of external circumstances.

FLUORESCENT LIQUIDS.

Mr. Ladd also showed some beautiful specimens of fluorescent liquids illuminated by the oxy-hydrogen light. They were similar to those which he showed at the British Association meeting at Glasgow last autumn, and their characteristic peculiarity consisted in the great difference of their colors when viewed by transmitted or reflected light. The following table shows the characteristic colors of—

Substances.	Transmitted.	Reflected.
Quinine	Transparent and colorless	Pale blue
Æsculine	Straw color	Pale blue
Amido-pthalic acid	Pale yellow	Pale violet
Amido tereph-pthalic acid	Pale green	Bright green
Paviine	Pale green	Blue green
Fluorescine	Orange red	Intense green
Eosin	Orange	Gamboge
Rose of Magdala	Carmine and clear	Opaque scarlet
Saffronin	Crimson	Dirty yellow

the principal fluorescent solutions. The first column is a list of the substances, and the second and third columns give their corresponding colors when seen by transmitted or by reflected light respectively.

ELECTRICITY OF PLANTS AND ANIMALS.

In the principal library one of the most interesting objects was the apparatus which Dr. Burdon Sanderson, F.R.S., employs in his investigation upon the electricity produced by plants and animals during muscular contractions or other movements in the latter, and sensitive motions, as in the Dionæa or Venus's flytrap in the former. By means of a minute Lippman's electrometer, placed under a microscope, Dr. Burdon Sanderson showed the electrical effect produced by the muscular contraction of the heart of a frog which had been removed from the animal twelve hours before. The base of the heart was imbedded in pipeclay moistened with a solution of sodium chloride, which was connected by means of an unpolarizable conductor to one electrode of the electrometer. Around the apex of the heart was tightly tied a silk thread moistened with the same saline solution and connected by a similar conductor to the other electrode. Metallic conductors have to be avoided in connection with the heart itself; as they would, even if made of the same metal, in the presence of the saline juices contained in it, act as a minute voltaic couple upon so sensitive an electrometer and invalidate the physiological results. By means of good illumination and a magnifying glass the heart could distinctly be seen to contract at intervals of about ten seconds (although so long removed from the animal), and each pulsation was accompanied by a corresponding movement of the mercury in the capillary tube of the electrometer, indicating a difference of electrical potential between the apex and base of the heart. This electrical impulse does not occur at the moment of contraction, but about one-sixth part of a second before it. It seems, in fact, to accumulate its energy previous to making the muscular effort for contraction. When the heart is at rest its apex is slightly *negative* to its base, but at about one-sixth of a second before it contracts, its apex becomes suddenly *positive* to its base, and is indicated by the pulsation of the mercury in the capillary electrometer. This instrument is small enough to be placed on the stage of an ordinary microscope not measuring more than about 5 in. by 2 in., and is capable of indicating differences of potential equal to that of about one-thousand part of a Daniell's cell.

THE HARMONOGRAPH.

Mr. Tisley showed his very beautiful harmonograph, by which Lassajous' and Melde's figures may be drawn upon paper by a capillary glass pen containing a colored ink. In its simplest form it consists of two heavy pendulums vibrating in planes at right angles to one another, and having their rods continued above their centers of oscillation. One of these rods carries a small flat table upon which is fastened the paper upon which the figure is drawn, and the other actuates a rod which carries the pen. The center of gravity, and therefore the time of oscillation of the latter pendulum can be altered to any required amount, so that the proportions between the periods of vibration of the two pendulums can be brought to any desired ratio to represent harmony, unison, discord, or indeed to illustrate all the harmonic combinations of waves of sound and music. The curves and figures traced out by this instrument are of great beauty, and by a recent addition to it, whereby the paper may be slowly rotated by a clockwork movement while the vibrations are going on, very extraordinary figures are produced, some of which illustrate in a remarkable degree the laws of interference and of the polarization of light Mr. Tisley also exhibited Professor Dewar's electrometer.

THE CYCLOSCOPE.

Professor M'Cleod showed a very interesting apparatus to which he has given the name of the cycloscope, by which the speed of machinery or of other rotating bodies may be determined with minute accuracy by an optical method of comparing the vibrations of a tuning-fork or reed of known period with the passage of fractional portion of one revolution of the body whose speed is to be determined.

Attached to this body and rotating with it is a disk of cardboard perforated in concentric circles by series of holes at equal distances apart; a powerful light is placed behind this disk, and a mirror attached to a tuning-fork forms, by the help of a lens, images of the holes as so many bright spots of light on a screen when the instrument is at rest. Upon causing the fork with its mirror to vibrate, these spots are drawn out into lines whose length is determined by the amplitude of vibration of the fork. While this vibration is going on if the disk be rotated the images of the holes on the screen are again displaced, partaking of the motion of both the fork and the disk, and become converted into very beautiful wave-like curves interlacing one another, and which, according to the speed of rotation of the disk as compared to the number of vibrations of the fork, appear either stationary or moving toward the right or toward the left, and when the number of holes per second passing the axis of the apparatus is equal to the number of vibrations of the tuning-fork the wavy line becomes steady and stationary, and as the number of holes in each concentric ring of perforations is known, and the number of vibrations of the fork is also known, it is a matter of simple calculation to determine the speed of the disk.

NEW SPECTROSCOPES.

Mr. Browning exhibited a spectroscope of great dispersive power by which an extraordinary separation of the D lines of sodium was effected. Messrs. Cecil and Leonard Wray exhibited their improved form of Clamond's thermo-pile and specimens of Gray's telephone.

Colonel Campbell (who it will be remembered conducted the Thebes station for the observation of the late transit of Venus) exhibited a very fine automatic spectroscope, which can be used with two, four, or six prisms, and having an arrangement in connection with the slit whereby any lines in the spectrum may be measured. He also showed a heliosta, in which the reflector consists of a very large prism of crown glass. This apparatus is not automatic, but is actuated by a very delicate worm and wormwheel adjustments. In addition to these, Colonel Campbell showed a very beautiful governor for regulating the speed of an 18-in. reflecting equatorial telescope, and which is fitted with an adjustment whereby the rate of the telescope can be varied to the extent of five seconds per minute. This variation can be given to the instrument while in motion, so that its speed is under complete control by the observer at the telescope. It consists of a regulating fly, the vanes of which are composed of "hit and miss" valves similar to the ventilators that are sometimes fitted into window-panes, and they are opened or closed by levers attached to a tube sliding up and down the spindle of the fly. The sliding of this tube is effected by a clutch and forked lever actuated by an ordinary steam engine governor in miniature, and the amount of its leverage may be varied by a screw adjustment with a micrometer head also acting through the centers of rotation, so as to be adjustable while the vanes are in motion. The general principle of adjustment is analogous to that by which the blades are set in Maudslay's feathering screw for steamships. All these instruments were made by Mr. A. Hilger, and exhibit great beauty of design and workmanship.

Mr. W. H. M. Christie, of the Royal Observatory, Greenwich, exhibited a large half-prism spectroscope, in which one, two, or perhaps three half prisms may be used, so as to give either great dispersion or great purity of spectrum. The arrangement of these prisms, as well as their form, is quite different to the ordinary construction and would require a diagram to make their form and disposition clear. This instrument was also constructed by Mr. Hilger, and is intended for use in the Royal Observatory.

ELECTRIC CHRONOGRAPH.

Captain Watkin, R.A., exhibited a series of instruments for assisting artillery operations in time of war, and an electric chronograph for measuring very minute intervals of time by the free fall of a weight. These also would require drawings and more space than we can spare on the present occasion to render them intelligible to our readers.

GREAT INDUCTION COIL.

In the meeting-room of the Royal Society, Mr. Spottiswoode, Treas. R. S., showed his giant induction coil. Discharges through large vacuum tubes by this fine instrument illustrated in a remarkable manner the two induced currents produced by the "make" and the "break" of the primary current as well as the striæ and stratification of the discharge.

The soirée was very largely and influentially attended; there were but few absentees of men celebrated in science, and among other eminent guests we noticed the Marquis of Salisbury, the Poet Laureate, the Duke of Teck, Dr. Schliemann, and Sir George Nares. We are only expressing the feeling of every one who was present when we congratulate Dr. Hooker and his Council on the eminent success of the evening.—*Engineering.*

THE ATTRACTIVE FORCE OF THE ATOM IN COMBINATION.

By D. P. Blackstone.

The single atom is a solid form, having dimensions too small to subtend a measurable angle. It is taken as granted that its attractive force varies directly as its quantity of matter and inversely as square of distance.

Atoms in combination take on a form, the dimensions of which subtend a measurable angle, and their joint attractive force on an atom outside of the combination must be estimated in a resultant line as the attracted atom cannot move in a direct line to every atom of the combination.

It is also taken as granted that each atom of the combination contributes a force in the resultant measured in ratio of the square of the cosine of the angle formed with the resultant by line drawn from the attracted to the attracting atom. This is the law of the rectangle of forces applied to the decomposition of force.

THE SPHERE.

A solid of spherical form like the atom has an attractive force measured directly as quantity of matter, and inversely as square of distance. Its attractive force is the same as if all its matter was located at its center. This holds true regardless of the law of density of the sphere, providing everywhere at the same distance from its center, or each layer, so to speak, is uniformly dense.

In Diagram No. 1, let the circumference A, B, C, of which C is the center, be a circle of rotation on axis PA, or a sphere, and P the location of an atom attracted by this sphere. On line of CP describe the circle BCDP, of which O is the center. Let arc BCD be an arc of rotation on axis PC. In its cutting of the sphere, of which C is the center, it is a zone to a sphere, of which O is the center. Connect with lines the points P and B, P and D, B and C, D and C.

I. It is to be demonstrated that any atom in arc of rotation or zone BCD attracts atom P the same in resultant direction PC, as if the atom in the zone was located at C, the center of the sphere.

From the construction of diagram, lines PB and PD are equal, and line CP bisects the angle BPD, therefore equal atoms at B and D jointly attract P in line PC. It is evident that line PC is the resultant line for all atoms in arc of rotation BCD.

The attractive force of an atom at B, taken without reference to joint attraction with other atoms, for P is to the attractive force of like atom at C for P as $\overline{PC}^2$ to $\overline{PB}^2$. The atom at C is in the resultant, therefore its full attractive force represented by PB^2 is exerted to move P in resultant line PC. The atom at B exerts its force, represented by PC^2 on P in direction PB, making angle BPC with the resultant. The triangle BPC is right-angled at B, being inscribed in a semicircle. The force $\overline{PC}^2$ being decomposed per ratio of square on cosine of angle CPB, or square on hypothenuse ($\overline{PC}^2$) to square on base ($\overline{PB}^2$), or by decomposition of force $\overline{PC}^2$ per rectangle. BCLP gives $\overline{PB}^2$ as that part of the attractive force of atom at B, which attracts P in direction PC, or in resultants. Attraction of atom at B and at C can then be each represented by $\overline{PB}^2$. The same is true of all atoms in the arc of rotation BCD.

As the arc of rotation BCD cuts each layer of the sphere in a circle, the only thing essential as regards density is uniformity throughout each layer.

II. It is to be demonstrated that all the matter of the sphere can be represented on the arc of rotation or zone BCD by a certain amount of matter; under such a condition that it will attract the atom P at any distance the same as the sphere.

In the diagram draw the dotted lines P*a* and P*a*, each making the same angle with the resultant PC. Let these lines in their cutting of the sphere represent the section of a solid, resembling in form a truncated cone, of which *aa* is the diameter of its lower base, and *bb* that of its upper.

The surface *bb*, or quantity of matter cut from the outside layer of the sphere at *b*, is to the surface *aa* or quantity of matter cut from same layer at *a*, as $\overline{Pb}^2$ to $\overline{Pa}^2$. The attractive force at *b*, as regards distance, is to that at *a*, as $\overline{Pa}^2$ to $\overline{Pb}^2$. These two propositions combined give a ratio of equality. Hence, a quantity of matter at *b*, represented by a surface *bb*, attracts P the same as a quantity of matter at *a*, represented by surface *aa*. In same way it can be demonstrated that a quantity of matter at *c*, represented by surface *cc*, attracts P the same as that of either surface, *aa* or *bb*. Hence, quantity of matter in the outer layer of sphere at *aa* and *bb* may be represented at *c* by double the matter represented by surface *cc*, regardless of distance from center of sphere to P. This demonstration applies to the next layer of the sphere and so on to its center.

Any chord as *ba*, made by drawing line, as P*a*, is bisected by arc of rotation BCD, because any angle, as P*c*C, inscribed in a semicircle is a right angle. The same layers of the sphere, then, are cut by the chord part of any line, as P*a*, on either side of the arc of rotation BCD.

A little outside of *aa* draw two more lines from P, each making the same angle with resultant line PC. As far as these lines are chords to the sphere let them represent outside of lines *ba* and *ba*, the section of a solid representing a hollow truncated cone. The same demonstration already given applies to this hollow truncated cone, and all others necessary to be formed to transfer the whole matter of the sphere to the zone BCD.

The matter on the zone BCD, in accordance with demonstrations already given, can be transferred to the center of the sphere without changing its attractive force on atom P. If a part of the layers of the sphere are left out, or put into other layers, or the sphere becomes a hollow sphere, the above demonstration applies, because no part of one layer has been compared, or put in balance, with a part of another.

III. It is to be demonstrated that the sphere attracts the same as if all its matter was located at its center, and its law of attraction is the same as that of the atom.

It is true that the surface of the zone BCD is* equivalent in area to the circle ABD, or any great circle of the sphere of which C is the center. It has been demonstrated that the sphere at every distance attracts P in accordance with the same law; therefore, if at any distance it can be shown, that every atom of the sphere can be represented on zone BCD, it is true at all distances. Make CP infinite, then the truncated cone, and truncated hollow cones, become a cylinder and hollow cylinders. Under this condition every atom of the sphere is represented on the zone. This demonstration holds true to the difference of a mathematical nothing.

The same conclusion can be reached by making PC a finite distance and taking arcs *aa*, etc., infinitesimate.

THE OBLATE SPHEROID.

The oblate spheroid in its attraction on an atom at the pole, or at any distance vertical therefrom, follows the law of the sphere only when the attracted atom is at an infinite distance. At any finite distance the oblate spheroid attracts less than the same quantity of matter in a spherical form.

In diagram No. 2, let the ellipse, of which C is the centre, and AA and BB are major and minor axis, be an ellipse of rotation on minor axis BB, or an oblate spheroid. Let P in the line BB, produced, be the location of the attracted atom. On PC as a minor axis describe an ellipse similar to the ellipse of which C is the center. O is the center of this ellipse, and *aa* its major axis. Let *b* be its semi-minor axis, and *a* its semi-major axis. With C as a center and BB as a diameter describe a circle, and let this circle be a circle of rotation on axis BB, or a sphere containing the same quantity of matter as the spheroid. With O as a center and PC as a diameter, describe a circle. Let the elliptic arc DCK and the circular-arc ECE be arcs of rotation on axis BB or PB.

I. It is to be demonstrated that the combined or joint attraction of all the atoms in the oblate spheroid is the same

* In diagram No. 1 draw dotted line B*v*D. In circle ABD ordinate B*v* = $\overline{Av} \times \overline{Vn}$. Also in circle CBPD, B*v* = $\overline{Pv} \times \overline{Cv}$. Therefore

$$\overline{Av} \times \overline{Vn} = \overline{Pv} \times \overline{Cv}. \quad (1)$$

Let R be radius of circle ABD and *r* that of circle CBPD, then $\overline{Av}$ = R × $\overline{Cv}$ and $\overline{nv}$ = R − C*v*, and $\overline{Pv} = 2r - \overline{Cv}$. Substitute these values in equation (1), and it becomes

$$(R + Cv)(R - \overline{Cv}) = (2r - \overline{Cv})\,Cv, \text{ or}$$

$$R^2 - \overline{Cv}^2 = 2r\overline{Cv} - \overline{Cv}^2, \text{ or}$$

$$R^2 = 2r\overline{Cv}, \text{ or}$$

$$\pi R^2 = 2\pi r\overline{Cv}.$$

πR^2 equals area of great circle ABD, and $2\pi r\overline{Cv}$ equals surface of zone BCD.

at any one distance of P, as if located on the spheroidal arc of rotation, or zone DCK.

This can be demonstrated by a system of a truncated cone, and truncated hollow cones, as in the case of the sphere, providing any chord of the ellipse, as dR, made by drawing any line, as PR from P, cutting the ellipse of which C is the center, is bisected by the elliptic arc DCK.

Let g be the point where the chord d R is cut by the elliptic arc DCK. Draw line g C and produce it to points in the ellipse V and V. Through C draw QQ, parallel to PR. VV and QQ are conjugate diameters. Pg and Cg being supplementary chords to the ellipse, of which O is the center, are parallel each to each, to corresponding supplemen-

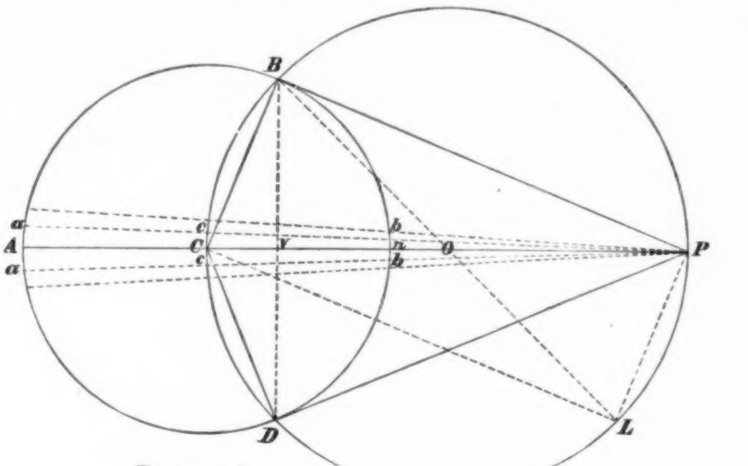


Diagram 1

tary chords to the ellipse, of which C is the center, hence, it is not necessary to draw the latter. The angle gPC is equal to angle QCB, because sides Pg and PC are parallel to CQ and CB, each to each, from construction. Angle PCg equals angle BCV, being opposite angles from the cutting of two lines. Since these supplementary chords make the same angles with the minor axis of the ellipse as the diameters QQ and VV, QQ and VV are conjugate diameters.

Draw du and Rw each parallel to gC and they are ordinates to diameter QQ, and of equal length, because parallels between parallels. This condition of equal ordinates from a well-known principle of Analytical Geometry, requires Qu to equal Qw, therefore Cu equals Cw, or gd equals gR.

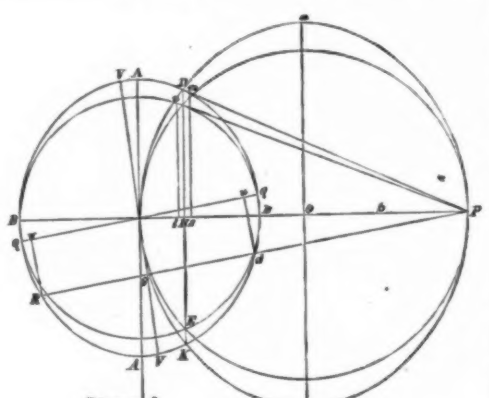


Diagram 2

II. It is to be demonstrated how much less any layer of the oblate spheroid of which C is the center and BB and AA minor and major axes attract atom P than the same quantity of matter in a corresponding layer of the sphere, of which C is the center and BB its diameter.

The demonstration to be given requires that the ordinate DH drawn from D, the point of cutting of the two ellipses, of which C and O are centers, shall pass through the point of cutting of the two corresponding circles.

The equation of the ellipse for the point D of the ellipse, with major axis AA, and minor axis BB, with origin of co-ordinates at the center C, gives:

$$x^2 \text{ or } \overline{DH}^2 = \frac{A^2}{B^2}\left(B^2 - y^2\right).$$

The equation of the ellipse for the point D, of the ellipse with center O, with major axis aa and minor axis bb, with origin of co-ordinates at C, the extremity of the minor axis gives:

$$x^2 \text{ or } \overline{DH}^2 = \frac{a^2}{b^2}\left(2by - y^2\right). \quad \text{Therefore,}$$

$$\frac{A^2}{B^2}\left(B^2 - y^2\right) = \frac{a^2}{b}\left(2by - y^2\right).$$

Since the ellipses are similar, the ratio or fraction $\frac{A^2}{B^2}$ is equal to ratio or fraction $\frac{a^2}{b^2}$. Dividing each member of this equation by this fraction and reducing for y

$$(1) \qquad y = \frac{B^2}{2b}.$$

Let E be the point of cutting of the two circles. The radius of the circle of which C is the center is B. The equation of the circle, for the circle of which C is the center, with origin of co-ordinates at its centre, for the point E gives:

$$x^2 \text{ or } \overline{EH}^2 = B^2 - y^2.$$

The equation of the circle for the circle with centers at O and origin of co-ordinates on the circumference at C, gives for point E:

$$x^2 \text{ or } \overline{EH}^2 = 2by - y^2. \quad \text{Therefore,}$$

$$B^2 - y^2 = 2by - y^2; \text{ or}$$

$$(2) \qquad y = \frac{B^2}{2b}.$$

The value of y in (1) and (2) are identical. Thus proving that y in each case represents the distance CH. Therefore the point of cutting of the two ellipses and the two circles are in the same line, DH perpendicular to PC.

The method of transferring and representing the atoms of the spheroid on the elliptic arc of rotation, or zone DCK, having been explained, the next step in the demonstration is to transfer these atoms to the circular arc of rotation or zone ECE.

Without reference to the resultant PC an atom at D, and a like atom at E, attract P as $\overline{PE}^2$ to $\overline{PD}^2$. The attractive force then of the atom at D can be represented by $\overline{PE}^2$, and that at E by $\overline{PD}^2$. Take Pn in extension of line PE, equal to PD and Pm in line PD equal to PE. Draw nl and ms perpendicular to PC. Per law of decomposition of force per rectangle of forces, $\overline{PS}^2$ represents that part of the attractive force of the atom at D, that attracts P in the resultant, and $\overline{Pl}^2$ that of atom at E.

From similar triangles Pms and PDH.

$$Ps : PH :: Pm \text{ or } PE : PD \text{ or}$$

$$\overline{Ps}^2 : \overline{PH}^2 :: \overline{PE}^2 : \overline{PD}^2 \text{ or}$$

$$\overline{Ps}^2 = \frac{\overline{PH}^2 \times \overline{PE}^2}{\overline{PD}^2}.$$

From similar triangles PEH and Pnl

$$\overline{Pl}^2 = \frac{\overline{PH}^2 \times \overline{PD}^2}{\overline{PE}^2}.$$

From these equations

$$\overline{Ps}^2 : \overline{Pl}^2 :: \frac{\overline{PH}^2 \times \overline{PE}^2}{\overline{PD}^2} : \frac{\overline{PH}^2 \times \overline{PD}^2}{\overline{PE}^2}, \text{ or}$$

$$(3) \qquad \overline{Ps}^2 : \overline{Pl}^2 :: \overline{PE}^4 : \overline{PD}^4.$$

The line PH being equal to y, and CH equal to $2b - y$, the ordinate of the circle $\overline{EH}^2 = (2b - y)\, y$.

Per right angle triangle PEH.

$$\overline{PE}^2 = (2b - y)\, y + y^2 = 2by, \text{ or}$$

$$\overline{PE}^4 = 4b^2y^2.$$

The ordinate of the ellipse $\overline{DH}^2 = \frac{a^2}{b^2}(2b - y)\, y.$

Per right angle triangle PDH.

$$\overline{PD}^2 = \frac{a^2}{b^2}(2b - y)\, y + y^2 = \frac{(2a^2b - a^2y + b^2y)}{b^2}\, y.$$

$$\overline{PD}^4 = \frac{(2a^2b - a^2y + b^2y)^2}{b^4}\, y^2.$$

Substituting these values of $\overline{PE}^4$ and $\overline{PD}^4$ in proportion (3),

$$\overline{Ps}^2 : \overline{Pl}^2 :: 4b^2y^2 : \frac{(2a^2b - a^2y + b^2y)^2}{b4}\, y^2, \text{ or}$$

$$(1) \qquad \overline{Ps}^2 : \overline{Pl}^2 :: 4b^6 : (2a^2b - a^2y + b^2y)^2.$$

$\overline{Ps}^2$ may be interpreted as the attractive force on atom P of all the matter of the oblate spheroid, represented on the elliptic arc of rotation, at a distance of DC from the center of the spheroid, and $\overline{Pl}^2$ as that of the same matter on circular arc at distance EC from the same center.

The matter represented on elliptic arc of rotation DCK at any point from D to C can be transferred to corresponding circular arc ECE by describing a similar ellipse through that point with C as a center, and a circle with diameter of minor axis of that ellipse with C also as center.

It is evident from the demonstration given that the density of the spheroid from circumference to center must be known, or some circumference with C as center, and lying in the elliptic arc of rotation or zone DCK found, in which all the matter of the spheroid can be represented, and attract atom P the same as the oblate spheroid, before a computation can be made, showing how much less the spheroid attracts atom P than the same quantity of matter in a sphere.

It is also evident if the factor of density can be eliminated, and it can be determined how much less the oblate spheroid attracts an atom at its pole, than the same quantity of matter in a spherical form, then the density of the spheroid, from center to circumference, can be computed.

These demonstrations then are comparatively worthless, unless some method is devised to eliminate the factor of density. In the case of the earth, there is data from pendulum experiments to eliminate the factor of density, as the following formulæ — the results obtained from accurate demonstrations—will show:

THE PROLATE SPHEROID.

The prolate spheroid attracts an atom at its pole, or vertically therefrom, more than the same quantity of matter in a sphere of diameter of major axis.

By method of demonstation similar to that given for the oblate spheroid result is obtained as follows:

Attractive force of the quantity of matter represented on elliptic arc of rotation or zone, at any distance from the pole of that zone, to attractive force of the same quantity of matter on corresponding circular arc of rotation, as

$$(2) \qquad 4a^6 : (2b^2a - b^2x + a^2x)^2.$$

From a system of demonstration requiring one change in diagram structure, viz.: making the elliptic arc of rotation change its form as it rotates, to meet the conditions of the ellipse it is cutting, and in one position it cuts a circle, I obtain a result as follows: for an oblate spheroid at its equator—the first two terms of the proportion being omitted:

$$(3) \qquad :: 4a^6 : \left[2\left(\frac{a+b}{2}\right)^2 a - \left(\frac{a+b}{2}\right)^2 x + a^2x\right]^2$$

The above is stated in terms approximate, but in the case of a spheroid having polar to equatorial diameter in ratio of 292 to 293, the approximation deviates no more from the truth than a table of sines and cosines, or tangents and cotangents.

By an additional improvement in diagram structure, a construction from which it can be determined by what angle a plumb line at any latitude deviates from passing through the centre of the spheroid when its density is known, I obtained the results for any latitude of the oblate spheroid as follows:

From equator to 45° latitude—

$$(4) \qquad :: 4a_1^6 : \left[2\left(\frac{a+b_1}{2}\right)^2 a_1 - \left(\frac{a+b_1}{2}\right)^2 x + a_1^2x\right]^2$$

From 45° to pole—

$$(5) \qquad :: 4b_1^6 : \left[2\left(\frac{a+a_1}{2}\right)^2 b_1 - \left(\frac{a+a_1}{2}\right)^2 y + b_1^2y\right]^2$$

a_1 and b_1 represent conjugate diameters.

The above results as regards their approximate correctness when applied to the earth, have an additional error, expressed by that part of the force of gravity which causes a plumb line to deviate from passing through the centre of the earth to the whole force of gravity.

If the attracted atom P is at the pole, in formula (1), a equals $\frac{A}{2}$, or one-half of equatorial radius, and b equals $\frac{B}{2}$, and formula becomes:

$$:: \frac{B^6}{16} : \left(\tfrac{1}{4}A^2B - \tfrac{1}{4}A^2y + \tfrac{1}{4}B^2y\right)^2, \text{ or}$$

$$:: B^6 : (A^2B - A^2y + B^2y)^2$$

Formula (3) becomes

$$:: A^6 : \left[\frac{(A+B)^2A - (A+B)^2x + A^2x}{4}\right]$$

Make x and y in the above expressions zero, and substitute for A and B equatorial and polar radii of the earth or 293 and 292 or 289 and 288. Represent the attractive force of the earth having a spherical figure at a distance of an equatorial radius from its center by unity. It results then from the above expression that the attractive force of the earth at its pole at an equatorial distance from the center, the earth having its existing figure is less than unity by a difference very nearly double the difference that the attractive force at the equator, after correction for centrifugal force, is more than unity.

The attractive force of the earth vertically from the pole at a distance of an equatorial radius is represented, in distance a body falls in a second of time by 16·0185 feet nearly, and at the equator after correction for centrifugal force 16·10185 feet nearly, using 293 and 292 for equatorial and polar radii. The difference is ·08335 feet. One-third of this is ·02778 feet, and two-thirds ·05555 feet. Making y zero in the formula for the pole gives a difference very much too large. To get the correct difference it is necessary to make y equal to three-fourths of B. In that case the whole mass of the earth is represented per diagram No. 2, in the circumference of a circle lying in circular arc of rotation or zone ECE, described at a radius distance of one-half of B from C. This is a condition requiring very great density at the center of the earth. The balancing of each layer of the earth on that circumference as a fulcrum per conditions of these demonstrations will solve the question of the earth's density at any distance from its center.

The attractive force at the pole is:

$$:: 16B^4 : (A^2 + 3B^2)^2 = \frac{16B^4}{(A^2 + 3B^2)^2}.$$

Attractive force at the equator:

$$16A^4 \text{ to } \left[\left(\frac{A+B}{2}\right)^2 + 3A^2\right]^2$$

From equator to 45° latitude—

$$16A_1^4 \text{ to } \left[\left(\frac{A+B_1}{2}\right)^2 + 3A_1^2\right]$$

From 45° latitude to pole—

$$16B_1^4 \text{ to } \left[\left(\frac{A+A_1}{2}\right)^2 + 3B_1^2\right]^2$$

A_1 and B_1 representing semi-conjugate diameter.

Using 293 and 292 for equatorial and polar radii, attractive force at pole is 292 to 293; at equator, 586 to 585; at 13 lat., 6 6 to 685; at 18° 18', 826 to 825;—26°, 1400 to 1399;—at 27°, 1572 to 1571;—at 28° 36', 1868 to 1867;—at 45°, 1167 to 1168. At not far from 34° ratio is unity.

The above figures are only approximate. A table of logarithms to 15 decimals used in computations would doubtless change the results somewhat.

After correcting the pendulum experiments for every latitude where they have been made, for centrifugal force, and to an equatorial radius and per results as given by these integrations, it is surprising how closely the experiments agree. They give results showing that a body should fall on conditions as above stated, 16·0735+0·0015 feet per second. This makes the moon's average distance 238,900 miles nearly.

At distance 56 equatorial radii in plane of the equator or no declination, attractive force is:

$$(12544)^2A^4 \text{ to } \left[\left(\frac{A+B}{2}\right)^2 + 12543A^2\right]^2$$

At 60 radii—

$$(14400)^2A^4 \text{ to } \left[\left(\frac{A+B}{2}\right)^2 + 14399A^2\right]^2$$

At 64 radii—

$$(16384)^2A^4 \text{ to } \left[\left(\frac{A+B}{2}\right)^2 + 16383A^2\right]^2$$

After making computations from these integrations and from integrations for moon's distances at various declinations, I found it unnecessary, as difference in attractive forces varies inversely as square of distance. For example, to find attractive force for 60 radii, no declination:

$$\frac{1}{586} \times \left(\frac{1}{60}\right)^2 = \frac{1}{2109600}$$

or attractive force at that distance 2109601 to 2109600.

It is evident from these demonstrations as an effect of the earth's figure the moon changes in velocity or time from declination and distance. The monthly period of inequality must then be between 27·21 days and 27·55. There must also be a periodic change between a revolution of the nodes and a revolution of the line of the absides. There is also another period extending over a long series of years.

I have hastily run over the computations, using a table of logarithms of 6 decimals, and where the tables were very unreliable did the work, not using the tables. The average force expressed in time that holds the periodic change to the nodal period may be represented by 43, and that which holds it to the anomalistic period by 85. This makes the monthly period not far from 27·44 days, and the second period not far from 17 years. The monthly inequality is only a fraction of a second. An accumulation of 8 or 9 years is between 5 and 10 seconds. I shall be prepared to give figures more reliable in a few weeks, computed with table of logarithms to 15 decimals.

WOOL DYEING.

By GEORGE JARMAIN.

(Continued from SUPPLEMENT No. 74.)

BLEACHING.

DURING the last few years a solution of sulphurous acid has been employed, to a considerable extent, for the bleaching of wool. Liquid bleaching presents many advantages over gas bleaching for loose wool, which is much more easily manipulated in a liquid than it can be in the sulphur chamber. On the other hand, sulphurous acid in solution is not as effective a bleacher as it is when in the gaseous state, and the solutions are troublesome to make, or more expensive to purchase, than the sulphur, which is the only article required in the gas bleaching process.

The solution of sulphurous acid used for bleaching purposes is one of the following:

1. A solution of the gas in water.
2. A solution containing from 3 to 5 per cent. of bisulphite of soda, to which an equal volume of hydrochloric acid is added.
3. A solution containing from 3 to 5 per cent. of the bisulphite, from which the sulphurous acid is set free in a subsequent operation.

The wool to be bleached should be well scoured with soap, washed, and steeped in one of the above solutions for some hours. If the first or second solution be employed, it will only require to be washed to free it from the acid; it may then be placed in a coach, and covered up with a sheet for some time, under which circumstances the bleaching action will be continued by the sulphurous acid remaining adhering to the wool.

If the third solution be employed, the wool, after draining, should be passed into water containing from 3 to 5 per cent. of hydrochloric acid, which will liberate the sulphurous acid from the bisulphite of soda with which the wool is soaked, and the sulphurous acid being liberated in contact with the fiber, and probably within the fiber itself, the coloring matter of the wool is acted upon more powerfully by this nascent condition of the bleaching agent than it is by free sulphurous acid. This method resembles the bleaching of cotton by bleaching powder, in the liberation of the bleaching agent by an acid.

Solutions Nos. 1 and 2 rapidly lose strength by the escape of the sulphurous acid, or by its conversion into sulphuric acid by oxidation. Some loss is, therefore, experienced when the bleaching is only required to be done occasionally. The sulphurous acid may be preserved in them to a considerable extent by neutralizing it with carbonate of soda; when required again it can be set free by the addition of hydrochloric acid. No. 3 solution holds its strength much longer than Nos. 1 and 2, and, although it requires a little more labor, the bleaching by it is more effective.

The following equation explains the action of the hydrochloric acid upon the bisulphite.

$$\underset{\text{Bisulphite of soda.}}{H\,Na\,SO_3} + \underset{\text{Hydrochloric acid.}}{HCl} = \underset{\text{Common salt.}}{Na\,Cl} + \underset{\text{Sulphurous acid.}}{H_2\,SO_3}$$

The color of the wool is often improved by tinting it with a little blue; this may be done in the acid bleaching bath, or, better still, in a bath specially made up for the purpose after the bleaching has been done. I have found a solution of indigo carmine to be best adapted for the tinting, but where the wool is very yellow it is necessary to use a red color in addition. The color may be given in the cold.

Bisulphite of soda solution of 45° Tw. is sold at the present time at 9s. per cwt.

When required in large quantities for bleaching purposes, or for the preparation of reduced indigo by Schutzenberger and Lalande's method, it may be made by absorbing in a solution of carbonate of soda the sulphurous acid gas produced by burning sulphur. The absorption may be made in a coffee still, or in a tower made of sanitary pipes filled with coke, or, finally, the gas may be absorbed by aspirating it, or by forcing it through the alkaline solution. The gas should be passed till after all effervescence has ceased, and until it is no longer absorbed.

The solution of bisulphite may also be prepared, if required in smaller quantities, by heating crushed charcoal soaked in strong sulphuric acid in an iron vessel, and conducting the gases evolved into a solution of carbonate of soda till saturated. And for small experimental purposes it may be made by heating in a flask strong sulphuric acid, to which is added either copper turnings or crushed charcoal, and conducting the sulphurous acid gas produced into a bottle containing solution of carbonate of soda, and shaking it up from time to time until no more gas is absorbed.

The following equations explain the reactions involved in the above operations:

$$\underset{\text{Sulphurous acid gas.}}{2SO_2} + \underset{\text{Water.}}{OH_2} + \underset{\text{Carbonate of soda.}}{Na_2\,CO_3} = \underset{\text{Bisulphite of soda.}}{2HNaSO_3} + \underset{\text{Carbonic acid gas.}}{CO_2}$$

$$\underset{\text{Sulphuric acid.}}{2\,H_2\,SO_4} + \underset{\text{Charcoal.}}{C} = \underset{\text{Sulphurous acid gas.}}{2\,SO_2} + \underset{\text{Carbonic acid gas.}}{CO_2} + \underset{\text{Water.}}{2\,OH_2}$$

$$\underset{\text{Sulphuric acid.}}{2\,H_2\,SO_4} + \underset{\text{Copper.}}{Cu} = \underset{\text{Cupric sulphate.}}{Cu\,SO_4} + \underset{\text{Sulphurous acid gas.}}{SO_2} + \underset{\text{Water.}}{2\,OH_2}$$

TINTING OR DYEING WHITE.

There are some descriptions of wool and woolen waste, the yellow color of which is but little affected by the action of sulphurous acid, but which may be very greatly improved in tone by tinting with the complementary colors, blue and red. The wool, waste, or cloth is well scoured in soap; the tinting bath is made by heating up water to about 120° and adding the tinting colors. Good proportions and colors for 250 lbs. yellow material I find to be—three tablespoonsful of Brook, Simpson, and Spiller's Humboldt; two tablespoonsful of Brook, Simpson, and Spiller's No. 1 B blue. Work in the bath for 40 minutes.

For some descriptions of goods other colors and proportions may be found to be better adapted; the above directions are merely intended to indicate the course to be adopted.

INDIGO.

The importance of this coloring agent in the woolen trade cannot be over-estimated; our finest and most expensive cloths are dyed with it, often with it alone, and frequently it forms the base upon which other colors are dyed.

Indigo has been known and used as a dye from the earliest times of cloth manufacture. It was employed by the Egyptians at a very early period, for it is found on mummy cloths; and the ancient Hindoos, Chinese, Greeks, and Romans were known to use it.

Indigo is a product of the vegetable kingdom, and is sometimes found in small quantities in animal secretions. Many attempts have been made to produce it artificially for industrial purposes, but as yet without result. The success which has attended the preparation of artificial alizarine, however, encourages the hope that at no distant day the production of artificial indigo for the use of the dyer will be added to the triumphs achieved by chemists in the production of tinctorial substances.

The plants from which indigo is derived belong chiefly to the family Leguminosæ and genius Indigofera. The species most cultivated and esteemed are: *I. tinctoria*, *I. disperma*, *I. anil*, *I. argentea*. The production of indigo is not confined to the Indigofera, for it is furnished also by the woad plant, *Isatis tinctoria*, belonging to the Compositæ family, and by other plants.

Indigo does not appear to exist in the plant in either of its well-known conditions, but is a product of a species of fermentation, to which the leaves are subjected during its preparation, the details of which I will not enter upon.

Asiatic indigoes are produced in Bengal, Oude, Coromandel, Manilla, Madras, and Java.

African, in Egypt, Mauritius, and Senegal.

American, in Guatemala, Caraccas, Mexico, Brazil, and Carolina.

The Bengal, Java, and Guatemala varieties are most esteemed. The Java is preferred for the manufacture of indigo carmine, on account of its purity of color. Its percentage of coloring matter is not very high, and the woolen dyer consequently prefers varieties richer in color.

The best varieties of Bengal indigo have a deep blue violet color. They are fine grained, and adhere to the tongue. They easily pulverize, and have a coppery hue when rubbed with the nail. Sp. gr. an average of ·769. The coloring principle upon which the value of indigoes mainly depends ranges from 12 to 72 per cent.

The examination of indigo, so far as it concerns the dyer, includes:

1. The determination of the percentage of mineral matter.
2. Its tinctorial power, compared with a standard sample of good indigo, or with indigotin, the pure coloring matter of indigo.
3. The amount of indigotin it contains as compared with a standard sample.
4. Its physical characters, such as its specific gravity, color, ease with which it powders, appearance when rubbed with the nail, action on the tongue, fracture.

1. The mineral matter is determined by burning in a platinum capsule, over a spirit lamp or Bunsen flame, a known weight, say 20 grains, of the powdered indigo, until all carbonaceous matter disappears, and weighing the ash. If 20 grains have been taken five times, the weight of the ash will give the percentage of mineral matter. The combustion will be complete in about an hour, but will be much facilitated by breaking the coke, and stirring it up at intervals with a platinum wire. Good indigo does not leave more than 10 per cent. of ash, and the best Bengal seldom more than 7 per cent.

2. Its tinctorial power is found, as compared with the standard sample, by placing 5 grains of each in a 2-oz. porcelain dish, pouring on each 5 cubic centimeters of strong sulphuric acid, or, better still, of fuming sulphuric acid, and digesting them for an hour or two at a gentle heat. Water is then added, and they are run into the 100 cubic centimeter measure, and then emptied into a beaker or flask to mix the solution. Five cubic centimeters of the sample under examination are then taken up with a pipette, and run into 100 cubic centimeters of water placed in a glass cylinder, or tall white glass bottle, and the solution of the standard sample is run into another 100 cubic centimeters of water, from a graduated pipette or from the burette, until a color is obtained equal to that of the sample under examination. The relative amounts of solution required to produce the same depth of color give the relative tinctorial values of the indigoes. Fifty cubic centimeters of the remainder of each solution are placed in a small pan, dish or beaker, along with 50 cubic centimeters of water, and swatches of woolen cloth of equal weight are dyed in them, the heat being raised nearly to the boil. The depth of color obtained in each case will give the relative tinctorial values of the indigoes.

3. To obtain the amount of indigotin, as compared with a standard sample, pour 10 cubic centimeters of the solution (as obtained in 2) into a pint of water contained in a flask or beaker, and run in from the burette a solution of permanganate of potash, until the blue color disappears and the solution becomes golden yellow. Treat 10 cubic centimeters of the standard solution in the same way. The number of cubic centimeters of permanganate required in each case gives the relative amount of pure indigotin in each sample. A convenient strength of solution of permanganate is made by dissolving five grains of the crystals in one liter of water.

Solutions of bichromate of potash or of bleaching powder may also be used for destroying the color of the indigo solutions, and the percentage of indigotin calculated from the amount of solution required in each case.

4. The examination of the physical characters of the indigo needs no comment.

Indigo, as met with in commerce, is insoluble in water, alkali, and dilute acids, and its treatment for bringing it into solution, in order that it may be used as a tinctorial agent, depends upon the fact that it is rendered soluble by the action of nascent hydrogen, whereby it is converted into white, or so called reduced indigo, which is then soluble in alkaline fluids, such as lime, soda, or potash. This is effected by various means, according to the class of goods which are required to be dyed with it. The vessels in which the goods are to be dyed are called vats, and the substances used to reduce or hydrogenize the indigo give the name to the vat. These vats may conveniently be divided into: 1. Cold vats: 2. Warm vats.

The cold vats are used for dyeing cotton or other vegetable substances; warm vats are invariably used for wool and woolen goods.

The following equation will explain the conversion of insoluble blue indigo into soluble white or reduced indigo:

$$\underset{\text{Indigo blue.}}{2\,C_8H_5NO} + H_2 = \underset{\text{Indigo white.}}{C_{16}H_{12}N_2O_2}.$$

Two molecules of the former being converted into one of the latter by the nascent hydrogen.

The following table exhibits the various materials and means employed to bring about the conversion and the name of the vat:

INDIGO VATS.

Copperas vat........	Cold....	Copperas, lime, and soda or potash.	....	Cotton and vegetable substances.
Woad vat	Warm..	Woad, madder, bran, and lime...	By fermentation, 140° F.	Wool and woolen goods.
Pastel vat..........	Warm..	Pastel, madder, bran, lime.......	By fermentation, not beyond 158° F....	Wool and woolen goods.
Pastel potash vat....	Warm..	Pastel, madder, bran, lime, potash: and, for some classes of goods, molasses..........	By fermentation, 120° F.	Wool and woolen goods.
Urine vat...........	Warm..	Urine, salt, madder..............	....	Useful for small dyers.
The German soda vat.	Warm..	Bran, carbonate of soda, lime, molasses	By fermentation, 120° F.	Wool and woolen fabrics.
Schutzenberger and Lalande's vat.....	Warm or cold..	Zinc dust, bisulphite of soda, lime....	By simple admixture..	Wool and woolen in warm vat; cotton in cold.

In the copperas vat, in which a mixture of copperas and lime is employed, the nascent hydrogen is produced as follows: The lime precipitates ferrous hydrate (hydrate protoxide of iron) from the copperas thus:

$$\underset{\text{Copperas.}}{FeSO_4} + \underset{\text{Slaked lime.}}{CaH_2O_2} = \underset{\text{Sulphate of lime.}}{CaSO_4} + \underset{\text{Ferrous hydrate.}}{FeH_2O_2}$$

The ferrous hydrate then takes up oxygen from water:

$$\underset{\text{Ferrous hydrate.}}{2Fe_2H_2O_2} + \underset{\text{Water.}}{2OH_2} = \underset{\text{Ferric hydrate.}}{Fe_2H_6O_6} + \underset{\text{Nascent hydrogen.}}{H_2}$$

Soda and potash, which are sometimes used in place of lime, act in the same manner.

In the fermentation processes, the woad, pastel, bran, and madder act as the ferments, by virtue of the nitrogenous matter which they contain; the sugar of the madder and the farina of the bran pass successively into grape sugar, lactic acid, and finally into butyric acid, the production of the latter being accompanied by the evolution of hydrogen and carbonic acid, the following equation representing the change:

$$\underset{\text{Lactic acid.}}{2\,HC_3H_5O_3} = \underset{\text{Butyric.}}{HC_4H_7O_2} + \underset{\text{Carbonic acid gas.}}{2\,CO_2} + \underset{\text{Hydrogen.}}{2H_2}$$

The nascent hydrogen thus produced is the reducing or hydrogenizing agent.

In Schutzenberger and Lalande's vat, the hydrosulphite, formed by the zinc acting on bisulphite of soda, decomposes water, taking up oxygen from it and liberating the hydrogen, itself passing into a higher state of oxidation. These changes are at present not very well understood.

The only vats employed in England for the dyeing of wool, so far as I can learn, are the woad vat, and that of Schutzenberger and Lalande. There seems to be a strong objection amongst English dyers to the employment of soda or potash, in consequence of vats being made caustic by the use of these alkaline carbonates along with lime. Caustic potash or soda is exceedingly prejudicial to the soundness and handle of the wool, especially when it is heated along with it; and Schutzenberger and Lalande's vat was not at first well received, because soda was used as the solvent of the reduced indigo, and many complaints were made that it rendered the pieces rotten. This is, however, now avoided by the use of lime only as the solvent, too great an excess of lime being carefully avoided.

UTENSILS.

The indigo mill is a very important apparatus. Unless the indigo is thoroughly ground great loss of that material

will take place. Indigo can only be reduced when brought into the condition of an impalpable powder. The mill is either constructed of stones, somewhat like those for grinding corn, and worked by a perpendicular shaft, or it consists of four iron rollers, which are rolled backwards and forwards in a trough by a cradle motion. The indigo is ground with water to a pulp, the operation being continued for several days. The pulp must feel perfectly smooth, and contain no gritty particles.

The vat is a cylindrical iron vessel, having a diameter and depth of 6 ft. 6 in. by 6 ft. 6 in. to 7 ft. 6 in. by 7 ft. 6 in. It is encased by an iron jacket or by brick work, and heated by steam, the steam space in the jacket being about 2 in. wide, and extending from the bottom to within 4 ft. of the top. Sometimes the vats are heated by a coil of copper pipe placed inside the vat, which is an economical arrangement. Direct fire heat is now but seldom employed.

Rakes are used to stir up the contents of the vats. The rake head is about 15 in. long by 5 in. wide, and the handle is 10 or 12 ft. long. The rake is lowered down to the bottom of the vat, and a portion of the sediment is drawn up with a jerking motion, when the head approaches the surface. Three or four men work up the vat in this manner vigorously for about ten minutes.

When not in use the vats are covered by a cover, in three pieces, made of battened three quarter inch boards. This keeps in the heat, and prevents oxidation of the vat liquor to a great extent.

A net of half inch meshes is lowered down into the vat when wool has to be dyed. The wool is gently moved about in the net by means of a "stang," care being taken that it is not lifted out of the fluid.

When the wool has been in the vat a sufficient length of time, it is lifted out of the net, and placed in a bag made of strong net. The wool is then wrung in the bag, and the liquid returned to the vat.

Pieces, when placed in the vat, are moved about by means of an instrument called a "hawk," one of which is held in each hand, and the piece is pulled towards the operator. It must not be raised above the liquor. In order to prevent the piece from sinking down into the sediment at the bottom of the vat, an iron hoop of the same diameter as the vat, covered with a net having 4 or 5 in. meshes, is lowered down about a yard below the surface of the liquid, and suspended there.

A movable squeezing machine, consisting of two iron rollers 6 in. in diameter, fixed in a frame work, serves the purpose of removing pieces from the vat. One or both rollers may be covered with vulcanized india-rubber.

MATERIALS USED IN THE WOAD VAT—WOAD, MADDER, BRAN, LIME, INDIGO.

Woad consists of the fermented leaves of the woad plant, *Isatis tinctoria*. This article is grown and manufactured largely in Lincolnshire. The seeds are sown in early spring, and when the plants are large enough they are transplanted in rows. When the plants are from 3 to 6 inches high, the outer leaves are twisted off by children, and then placed under a shed. Usually three crops are thus gathered during the season. The manufacture of the woad is carried on in the winter. The leaves are mixed with lime and urine, and thrown in a heap to ferment. The heap is repeatedly turned over with shovels to prevent excessive fermentation; this turning of the heap is continued until fermentation ceases; the woad is then packed in barrels and sent to the market. The present price of woad is from £26 to £30 per ton. (Sample exhibited.)

Madder contains sugar and nitrogenous matter in addition to its coloring matters. The sugar passes into the butyric fermentation, and furnishes part of the nascent hydrogen; the nitrogenous matter acts as a ferment. The ordinary crop madder is employed. The use of madder in the fermentation vats is not essential, and in many establishments it is not employed. The coloring matter of the madder gives a special shade to the indigo which some manufacturers like.

The bran used is the ordinary bran obtained in grinding wheat. It contains nitrogenous matters and starch; the former assists as a ferment, and the latter passes during the fermentation through the various stages of glucose, lactic acid, and butyric acid, nascent hydrogen being produced at the latter stage.

Newly burnt lime slaked and riddled is thrown into the vat in the powdered condition. Its employment serves the purpose of neutralizing the butyric acid as fast as it is formed. When the addition of lime is neglected too long, the butyric acid and other matters pass into the putrid fermentation, which acts destructively upon the indigo.

The indigoes found to be the most economical and effective for woolen dyeing are the medium qualities of Bengal, ranging, at the present time, from 4s. to 5s. per lb. The violet copper colored varieties, having a low specific gravity, are prepared. (Samples exhibited.)

PRELIMINARY OPERATIONS.

When the indigo-dyed goods are required to have a special "bloom," the wool or woolen fabric has a "bottom" put on it. Camwood, barwood, Saunder's-wood, cudbear, archil, or archil paste, are the coloring matters which are employed for this purpose. Camwood is the best for wool. The woods give a much more permanent bloom than the weed colors, cudbear and archil, which are somewhat fugitive.

The goods are boiled with the color for an hour or an hour and a half, no mordant being used. The quantity of ware is varied according to the depth of shade of bottom required; 16 lbs. of camwood or 12 lbs. of cudbear for 100 lbs. of wool are good proportions for a full bottom.

Of course the blooming is not the only object which the dyer has in view; economy of indigo is an important matter to him.

It is important that the goods to be dyed should be thoroughly cleansed from all dirt, grease, and soap, or otherwise the dye will be taken up unequally.

SETTING THE WOAD VAT.

The following is the method adopted in the woolen districts of the West Riding:

Dimensions of vat, 7 ft. diameter by 7 ft. deep.—Materials.

	£	s.	d.
5 cwt. Lincolnshire madder, at 26s.	6	10	0
3 pails of bran, weight 18 lbs.	0	1	1
22 lbs. slaked lime in dry powder	0	0	2½
2½ lbs. madder	0	0	10½
24 lbs. of indigo, at 5s.	6	0	0
	£12	12	2

The woad is chopped and pounded with a spade until the pieces are no larger than a hen's egg. It is thrown into the vat, which is then nearly filled with water. The contents are now heated by turning on the steam, until a temperature of 140° to 150° F. is obtained. The vat is stirred up three or four times at intervals of 15 minutes, and then left over-night. The wood will now be soft and pulpy. Next morning put in the bran, madder, indigo reduced to a smooth paste by grinding, and half the lime, rake up, cover over, and leave till next morning. If the fermentation has commenced, the vat will present the following appearances: A slight froth will rise to the surface when the bottom is slightly stirred with one rake. The liquid, when stirred, will appear green-yellow with blue veins or streaks, the green color predominating. A coppery blue scum called "flurry" will appear on the surface of the vat. A portion of the bottom drawn up with a rake will show signs of fermentation, and will smell slightly sour. A piece of wool put into the liquid for a short time will be dyed. If these appearances present themselves the vat is progressing favorably, and about a quart more lime may be added, and the whole well raked up. If no signs of fermentation appear, more time must be given before adding the lime, which in this case would only have the effect of retarding the fermentation. If the vat matures satisfactorily, a quart more lime may be added every two or three hours, stirring up well after each addition. The coppery blue flurry will increase in quantity, and the liquid, when stirred, will be green-yellow with blue streaks. Then heat up to 140°, cover, and leave overnight. Next morning (the third morning), if the fermentation has proceeded satisfactorily, the vat may be used for dyeing. It is very important that great caution should be exercised in the addition of lime, for if the vat be overdosed fermentation will be arrested, and there will be considerable difficulty in re-establishing it. The vat will then have to be left probably for several days before the fermentation reappears. On the other hand, if the addition of lime be neglected too long, and the fermentation passes to the putrid stage unchecked, the indigo will be lost, or, as the dyers say, it will "run away." The liquid exhales an agreeable odor when the progress of the setting is proceeding satisfactorily, but the odor changes when too much or too little lime is present. Much depends on the care and skill of the dyer, for no description of the process can accurately convey to the mind of the uninitiated the mode to be adopted, in the varying conditions to which the fermenting indigo vat is subject. An experienced indigo dyer can exercise perfect control over the condition of his vat.

The following account of the setting of two indigo vats last week, of which I took notes, may be useful:

The vats were intended for the dyeing of broad cloths and wool of a full blue.

Dimensions of vats 6 ft. 6 in. by 6 ft. 6 in.—On Wednesday at noon the vats were filled with water, and 4½ cwt. of crushed woad were put into each vat; the liquid was heated to 140° F., and stirred up once. On Thursday morning they were heated up again to 140° and kept at that temperature all day. During the day they were raked up vigorously by four men four times. At 5 o'clock P.M., 25 lbs. of indigo, well ground to a smooth paste, 14 lbs. madder, 5 quarts of lime, and 4 pails of bran (2 gallons each), were added, and the whole well stirred up and left overnight. On Friday morning at 9 o'clock a light froth rose on the surface, when the vat was gently stirred up with one rake. The bottom was in a slight state of ferment and smelt rather sour. The liquid appeared green-yellow on the surface, with blue streaks when it was stirred by the hand. (Sample of wool dyed in it exhibited.) One quart of lime was added to each vat, and the contents well stirred for ten minutes as before. It was then covered up. At 11 A.M. and at 1 P.M. another quart of lime was given, and the contents raked up as before. A considerable quantity of coppery blue flurry had now accumulated on the surface, and the liquid appeared of a dark greenish yellow with blue streaks when disturbed by the hand. The odor was favorable and the fermentation steady, being kept under by the lime. At 3 P.M. the vats were warmed to 135° and another quart of lime added and again well stirred up, appearances and odor favorable as before. At 5:30 the vats were in a condition fit to use for dyeing. (Sample dyed exhibited.) Three pints of lime were given to each vat and 5 lbs. more indigo; they were well stirred up; temperature 130°. They were covered up and left over night. At 9 A.M. on Saturday, 2 sixty yard pieces of narrow doeskins were put into each vat, and after they had been worked for 1½ hours I took off a sample and left them. (Sample exhibited.)

THE DYEING OPERATIONS.

Pieces to be dyed a full blue are hawked in a strong vat from 20 minutes to 2 hours, according to the class of goods, heavy and closely woven fabric requiring more time for the color to penetrate into the center than lighter and more open goods. The material is then drawn out of the vat, and after exposure to the air for some time, in order that the reduced indigo may become oxidized and pass into the blue and insoluble condition, the goods are passed into a weaker bath, to dye up to the shade required. For light blue colors, such as are given for wooding for blacks, a single working through a moderately weak bath for about 20 minutes will be sufficient.

For dyeing wool, a vat which shows the fermentation to be in a moderately active state is found to be the best, but pieces are dyed more perfectly in a vat in which the fermentation is kept under.

When the goods are withdrawn from the vat, they are of a fine green color, which rapidly passes to blue. The green color is due to the instant oxidation of a portion of the yellow-colored reduced indigo, which thus produces a mixture of blue and yellow.

The formation of indigo blue from the reduced indigo is explained by the following equation:

$$\underset{\text{Indigo white.}}{C_{16}H_{12}N_2O_2} + \underset{\text{Oxygen from the air.}}{O} = \underset{\text{Indigo blue.}}{2\,C_8H_5NO} + \underset{\text{Water.}}{OH_2}$$

For keeping up the strength of the vat, about 15 lbs. of indigo are added every other day, more lime and bran being added every day. After finishing the day's working of the vats the necessary addition of bran, lime, and indigo is made, and the vats well raked up and heated up to 140° F.

The following table gives the quantities and cost of materials used in a large dye house, for the woad vat for dyeing dark indigo blues on cloth (sample exhibited):

	£	s.	d.
6,533 lbs. indigo, at 5s. 6d. per lb.	1,796	11	6
68 cwts. lime, at 1s. per cwt.	3	8	0
19⅞ packs bran, at 14s. 6d.	14	6	4
142½ lbs. madder, at 4¼d.	2	10	6
56½ cwts. woad, at 30s.	84	15	0
12 cwts. fuller's earth	1	16	0
	£1,903	7	4

Percentages of total cost:

Indigo	94·37
Fuller's earth	·10
Woad	4·45
Madder	·13
Bran	·76
Lime	·18
	99·99

Cloth dyed with the above materials, 159,180 lbs.; cost per pound, 3·67 pence.

It is noteworthy that the materials required to reduce the indigo only cost 5·52 per cent. of the whole.

SCHUTZENBERGER AND LALANDE'S VAT.

This vat stands in marked contrast to the woad vat already described, as regards time and the number of vats required. The reduction of the indigo is almost instantaneous; in fact, the reduced indigo may be prepared beforehand, and then it is only necessary to add it to the vat, and proceed with the dyeing in the manner already described. The reduction is performed in the following manner:

Materials required.—Bisulphite of soda, at 45° Tw., costing 9s. per cwt. Zinc dust, at 23s. per cwt. Slaked lime in powder, sifted, or in the form of cream of lime. Indigo, ground in water, in the form of pulpy paste, without any gritty particles.

Utensils for the preparation of the reduced Indigo.—A small tub, or pail, in which to prepare the hydrosulphite. A cask in which the indigo is reduced. Barrels in which to store the reduced indigo. The same vats and utensils which are employed with the woad vat.

To prepare the reduced indigo proceed as follows:

Pour bisulphite of soda solution into a pail or small tub, and add zinc dust until the smell of sulphurous acid disappears, stirring up well until this takes place. The zinc dust required will be from one fifteenth to one tenth of the weight of the bisulphite of soda. The solution so produced is called hydrosulphite.

Place your indigo paste in a cask or tub; add a little cream of lime, and heat to 120° F. Run in sufficient hydrosulphite to reduce the indigo, which may be known when the surface of the mixture assumes a dark green appearance: then add more cream of lime to dissolve the reduced indigo, when the mixture then becomes yellow. It may be known when sufficient lime has been added by taking out the stirring rod, which will quickly assume a bronzed, coppery appearance. If too much lime has been added, the indigo becomes brown, and is partly destroyed, a smell of ammonia being given off.

The creamy fluid is then run into barrels for use.

The principle on which the indigo is reduced has already been given. (A small sample of indigo was reduced.)

THE DYEING OPERATIONS.

The vat is filled up with water, which is heated up to from 130° to 140° F., and the necessary quantity of reduced indigo run in from the store casks. The dyeing may be carried out exactly on the same plan as with the woad vat; the vat may, however, be used continuously, as it may be fortified at any moment by the addition of reduced indigo. If the indigo in the vat should become oxidized by exposure to the air, and by the air which the goods carry in with them mechanically, it may be reduced by adding hydrosulphite, and also lime if necessary, to the vat. As there is not such an accumulation of solid matter at the bottom of the vat as there is in the woad vat, vessels having a much less depth may be employed.

The dyer very quickly learns how to manage this vat. The operations are simple and perfectly under control, and they do not, therefore, require an apprenticeship to learn how to manage them, as is the case with the fermentation process.

OPINIONS OF DYERS ON THE HYDROSULPHITE VAT.

Since the year 1873, when it began to be used in Yorkshire, the experiences of woolen dyers with this vat have been very varied. It has been abandoned by some and continued by others.

The advantages claimed for it are—that it is easy to manage; that it dyes worsted goods clean; that it can be used either for light or dark blues; that the services of an experienced blue dyer at high wages can be dispensed with; that it is rapid.

The disadvantages attributed to it by those who have abandoned it are—that it is much more expensive than the woad vat, on account of loss of indigo in washing; that the goods handle thinner when of the same weight and texture, although the strength of the goods is not impaired, as tested by Hebden's machine; that the color is not quite so good, being somewhat green; that it requires one third more red bottom than the woad vat; that it spoils the face of goods.

The heaviest charge against it, however, seems to be the cost, but this may be very greatly lessened by recovering the indigo which washes off, by passing the goods through milk of lime before the washing. The lime dissolves the reduced indigo which has not become fixed to the fibre. The green color can be removed by passing the goods through very dilute sulphuric acid in the washing machine.

The following table gives the cost of dyeing dark blues by the hydrosulphite vat, by a dyer who wished to use it, but was deterred by the cost. It bears unfavorable comparison with the cost of materials by the woad vat. The cost of labor in working the two vats may be assumed to be about the same:

	£	s.	d.
240 lbs. indigo, at 5s. 6d.	66	0	0
1,978 lbs. bisulphite of soda, at 1d.	8	4	10
195 lbs. zinc dust, at 23s. per cwt	2	0	1
30 lbs. fuller's earth	0	1	0
Lime	not given		
	£76	5	11

Percentages of total cost:

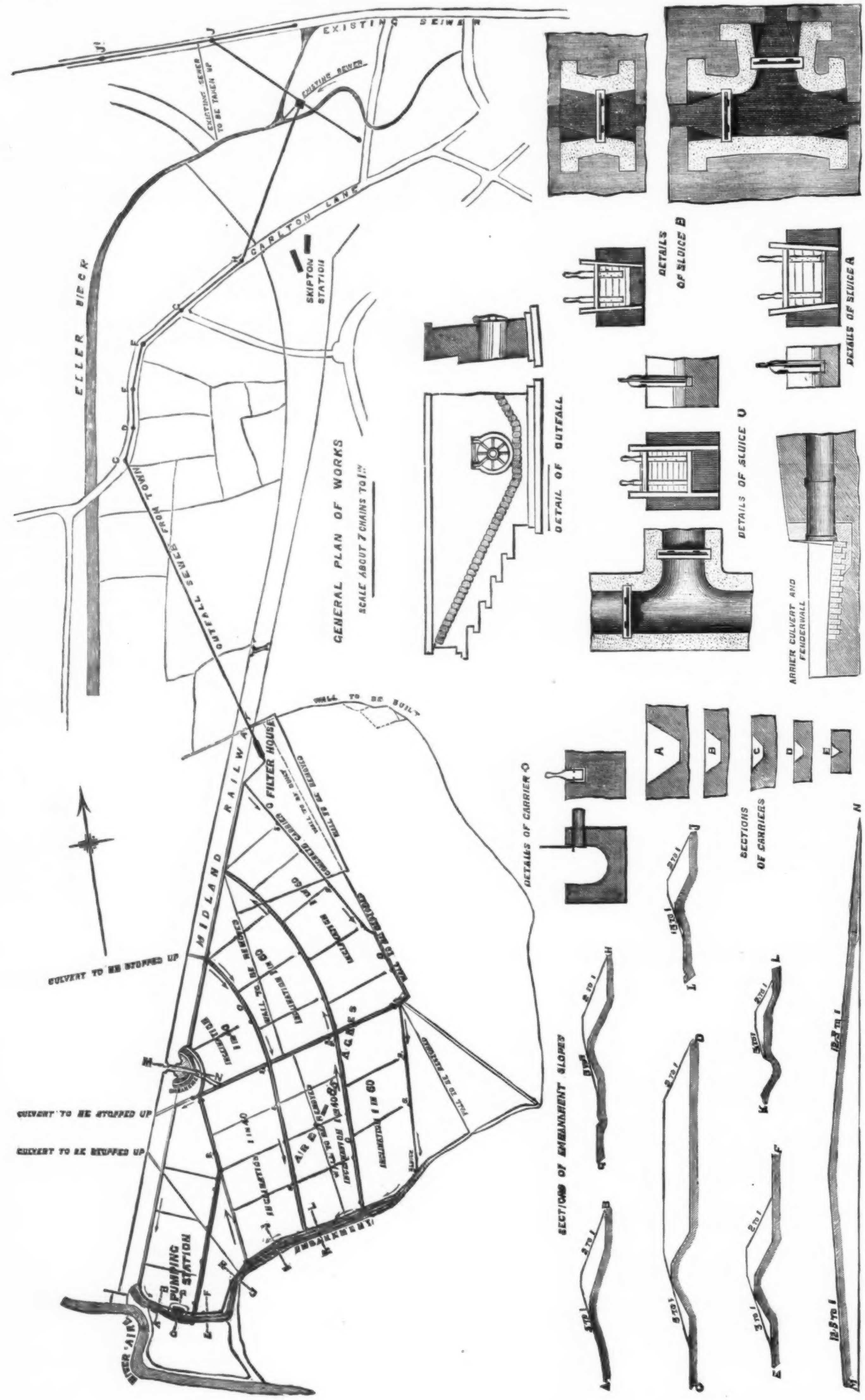
Indigo	86·84
Bisulphite soda	10·62
Zinc dust	2·63
Fuller's earth	nil.
Lime	not given
	100·09

Cloth dyed with above materials, 3,420 lbs. Cost per lb., 5⅜d.

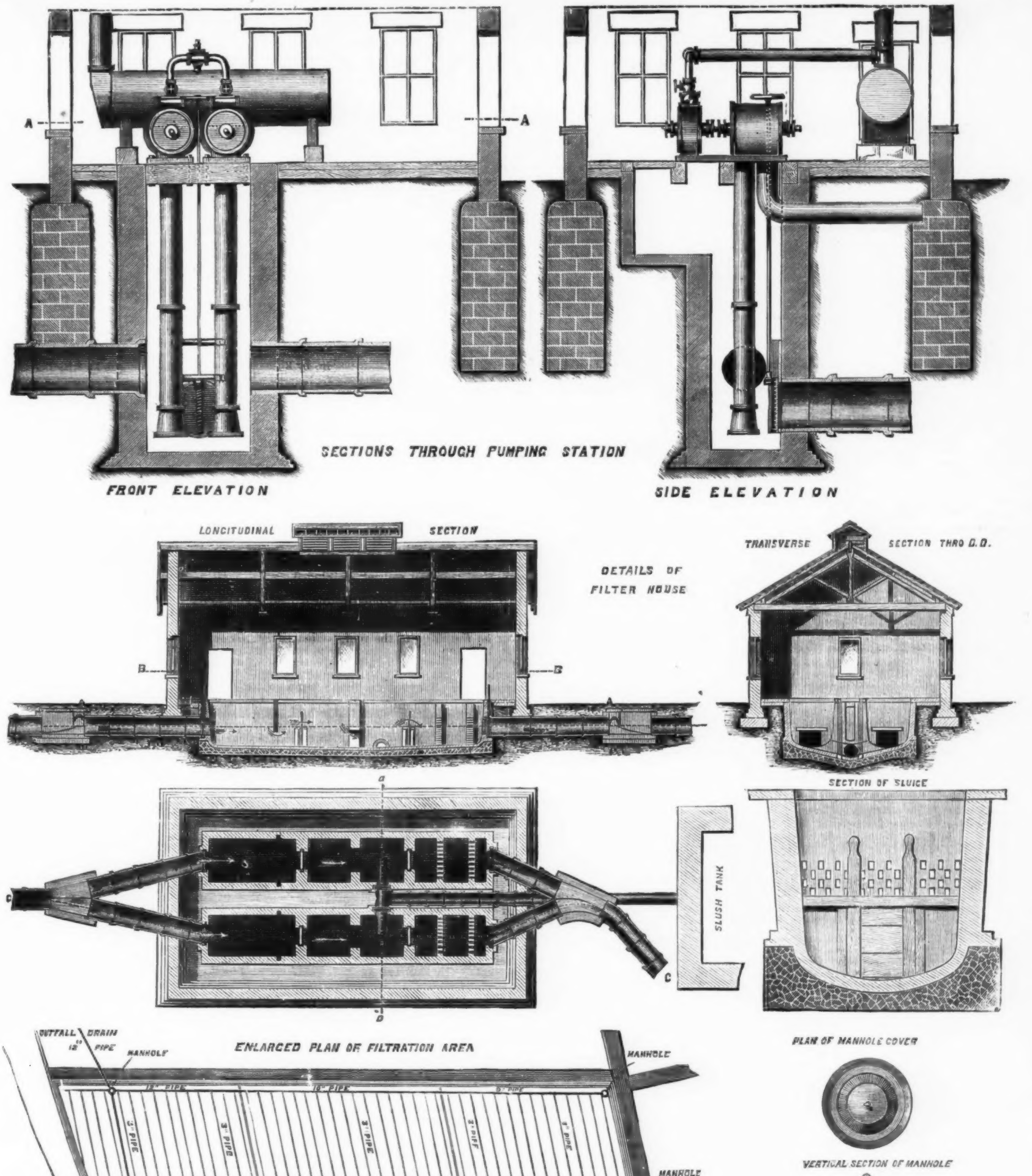
The materials required to reduce the indigo cost 13·25 per cent. of the whole.

(Wool and swatches of cloth were then dyed with the hydrosulphite vat.)

(To be continued.)



SEWAGE WORKS FOR SMALL TOWNS. DESIGNED BY BALDWIN LATHAM, C.E., FOR THE TOWN OF SKIPTON, YORKSHIRE, ENG.



SEWAGE WORKS FOR SMALL TOWNS. DESIGNED BY BALDWIN LATHAM, C.E., FOR THE TOWN OF SKIPTON, YORKSHIRE, ENG.

SEWAGE WORKS FOR SMALL TOWNS.

We give herewith designs by Mr. Baldwin Latham, C.E., as make for the town of Skipton, Yorkshire, England.

The design prepared by Mr. Latham supplies an admirable example of what the sewage works of a small town ought to be. They are of the simplest character. The general scheme is to utilize the sewage by irrigation, the sanitary authority having obtained 85 acres of land for this purpose, 36 acres 2 roods 10 perches of which are to be laid out for ordinary irrigation, and 5 acres 2 roods 16 perches for intermittent filtration. The general plan of the ground is fully shown in our engravings, which explain themselves. The effluent will find its way into the river Aire. This river, however, is very liable to flooding, so that the land upon which the sewage is to be applied is embanked against floods, and at such periods as the river is in flood pumping machinery will be employed to lift the effluent over the banks into the river. The machinery is of an extremely simple and inexpensive kind, and is the invention of Mr. C. Brakell.

The following is an abstract of the specification of works to be observed by the contractor in the construction of outfall works, and preparing, leveling, and laying down land in the neighborhood of Skipton, Yorkshire, for the reception of the sewage of Skipton, including all earthwork, concrete, cement, brickwork, earthenware pipes, woodwork, ironwork, steam pumping machinery, and other works required by the Skipton Local Board, acting as the urban sanitary authority of Skipton:

The contractor shall provide such steam or other engines, machinery, etc., as may be required for successfully carrying out the works without interruption or delay. The contractor shall provide all the materials, and all the labor required to execute and complete the whole of the works, in accordance with this specification and the drawings referred to, and he shall pay or provide for all carriage or cartage of the materials.

The whole of the materials used in the works shall be of the best quality and description of their several sorts, and they shall be built or put together in the best, most workmanlike and substantial manner, to the entire satisfaction of the engineer or his deputy, the resident engineer, or any inspector of works appointed by the engineer or the urban sanitary authority.

The contractor shall at his own cost keep the whole of the works during their progress in good condition and repair, and he shall restore and make good any damage they may sustain from any cause, so that at the termination of the contract the works may be perfect and complete. He shall also at his own cost maintain all the singular and several works in a state of perfect repair, order and condition, for a period of six calendar months, dating from completion, as certified by the engineer. The contractor shall also keep the drains and carriers constructed by him cleansed, and shall work the pumping engines as may be required, providing any engine drivers and stokers that may be necessary, and all fuel, oil, and waste, or other matters, and the contractor shall be responsible for the safety of the machinery during the whole six months the works are in his charge.

The quantities of the several works have been taken out from the drawings and this specification by Messrs. Hovenden, Heath, and Berridge, of 181 Bishopsgate street Without, E.C. A copy of such quantities, which will be furnished to the contractor, shall be filled in by him, with the prices upon which his contract is based, and it shall form the schedule of prices under this contract. This copy of the quantities so filled in shall accompany the tender, and all extra, reduced, or omitted works shall be valued by the engineer at the prices stated therein.

The contractor shall pay the surveyor's fees for taking out and computing the quantities; also, the cost of printing the specification, the schedule of prices, and the quantities; also fifteen guineas for a set of the drawings, and fifteen guineas for the legal expenses connected with the drawing up and sealing of the contract out of the first instalment on account of his contract. The quantities will not be guaranteed by the Urban Sanitary Authority or the engineer.

All the bricks to be used in the works shall be sound, hard burnt, and equal in quality to the respective sample bricks deposited in the office of the engineer. The bricks shall be well wetted before they are used, and soundly bedded in the work. The cross joints shall also be solidly flushed up the whole thickness of the work. The joints shall not exceed ⅜ of an inch in thickness, and shall be struck smooth and flush on the face.

The stone for the stonework shall be carefully selected. The contractor may, if he chooses, excavate the upper portion of the land, the property of the Skipton Urban Sanitary Authority, for the purpose of getting any materials that he may require for use on the works, but any excavations made by the contractor shall be leveled to the satisfaction of the engineer.

The contractor shall excavate the ground for constructing the drains, sewers, carriers, sluices, and other works to the necessary depths and inclinations, and also for the construction of the outfall works, engine and boiler house, and for any temporary purpose in connection with the works. In case any loose, soft, or bad ground is met with, the contractor shall excavate the same to a solid foundation, and shall fill up the excavation to the level of the sewer with concrete. For this excavation the contractor will be paid extra, but if he excavates in good ground below the proper level for the brickwork or the pipes, he shall fill up the excavation with concrete at his own cost.

All the sewer or other pipes shall be laid in open trenches, unless with the special sanction of the engineer adits or headings are permitted.

All the stoneware sewer and drain pipes shall have the thicknesses and dimensions, when burnt, as given below:

	In.	In.	In.	In.	In.
Size of pipes..............	6	9	10	12	15
Thickness of material	¾	⅞	1	1 1/16	1¼
Depth of socket, not less...	1¾	2	2	2	2¼

The pipes shall all be perfectly straight and truly cylindrical, salt glazed inside and outside, free from cracks and flaws, and perfectly burnt. Those not perfectly straight and truly cylindrical, well and uniformly glazed, free from fire cracks and flaws, and perfectly burnt, the engineer or resident engineer shall reject, and the contractor shall supply other pipes in their place. The pipes shall be equal in quality to the best country-made glazed socket pipes of Messrs. H. Doulton & Co., of Lambeth, or Messrs. Ingham & Sons, of Wortley, near Leeds

All junctions with the main pipe sewers shall be formed with curved pipes inserted in the sides in the direction of the streams, the main pipe being tangential to the junction. The ends of the curved pipes to radiate to the center from whence they are struck. All the junctions and all the bends, syphons, or other special pipes, shall be of the same thickness as the straight pipes, and every junction, bend, or other special pipe not of the same thickness shall be rejected. All junctions made with brick sewers shall be fitted with proper junction blocks built into the brickwork of the sewers.

The contractor, in laying the sewer and drain pipes, shall take care that they are laid perfectly solid, true to the inclinations, and straight from point to point of the manholes, ventilators, or lampholes. The earthenware sewer pipes, when necessary, shall be jointed by forcing two strands of tarred gaskets into the joints; the strands to be sufficiently thick to tightly fit the annular space between the sockets and spigots. The annular space shall then be solidly filled with neat Portland cement, and a fillet of cement worked round the outside of the joint. The pipes used for land drainage need not be jointed.

The contractors shall build all the manholes where shown on the plans and sections, or where directed by the engineer or resident engineer, in accordance with the detail drawings. The floors of all the manholes shall be constructed of brickwork in cement laid on concrete with proper channels formed across them, and cast iron foot-irons built in the brickwork.

The contractor shall supply the tankard valves and penstock, as shown on the drawings. The tankard valves shall all have V faces and lead seatings. The moving parts of the tankard valves shall be bushed with gun-metal.

The contractor shall build the engine and boiler house, sewage well and chimney shaft, as shown on the drawings. The external walls shall be built in local stone. All the external walls shall be built and neatly pointed with a trowel, both on the inner and outer face. The floor of the building shall be paved with Yorkshire flags 3 in. thick, bedded in Portland cement mortar. The contractor shall provide the framed, rebated, and moulded window frames, and 2 in. sashes, as shown on the drawings, and shall supply ¼ in. rough plate glass for filling in the windows. He shall also construct the doorways, and provide 2½ in. framed and filled in doors at the sides of the building, as shown on the drawings. He shall supply all the hinges, locks, bolts, fastenings, etc., required for three of the windows and for the doorways; and shall build in the external walls, frames 4½ in. by 4 in., required for securely hanging or fastening the doors and frames for the windows. He shall embank or excavate round the building in earthwork as shown on the drawings, and shall form the roads round the buildings. The contractor shall supply all the timber and other work. The timber for the roof shall be left rough from the saw. He shall construct the ventilator on the ridge of the roof, with iron finials, value 30s. each, as shown on the sections.

This ventilator shall be capable of being closed at pleasure, and the contractor shall provide all the cords, pulleys, and fastenings required for this purpose. The sills for the windows shall be chambered both inside and outside the building. He shall also supply the cast iron gutters and fix round the building, and also the drop spouts, and shall connect these rain-water pipes with the sewers, and he shall supply all the necessary glazed pipes for this purpose. The contractor shall three times lime-white the interior walls of the building, and shall three times paint all wood and iron work usually painted in good oil colors, as shall be directed. He shall board the roof with ¾ in. boarding, and shall cover it with approved Westmoreland slates, laid with a lap of not less than three inches. He shall supply the terra cotta ridge roll for finishing the roof of the building and ventilator. He shall also provide the wrought rafters as barge boards for the gables of the building, and shall perform all other work that may be necessary to complete this contract in a satisfactory manner. The timber used in the works, unless otherwise specified, shall be Memel of good quality.

The contractor shall fix the engine and boilers, as shown on the drawings, and he shall fix and set in the brickwork or stonework all the necessary iron work and fittings, blow-off and other pipes. He shall make all bolt holes, and cut out any brick or stone work that may be required for fixing the engines, boilers, or other machinery. In addition to the arches shown on the drawings, proper relieving arches shall be turned over all openings. Inverted arches shall be turned under doorways.

The whole of the stone used in the work shall be of the best description of their respective kinds, and shall be free from clay-holes, loose beds, shakes, cracks, or defects, and when fixed in the work shall be upon its natural quarry bed. The stonework shall all be properly coursed, prepared, disposed, and faced as required.

The contractor shall construct the engine, boiler, and pump beds as shown on the drawings, and shall provide all timber, concrete, and stonework for the purpose, and shall make all the necessary bolt and hand holes, etc., that may be required.

The contractor shall provide two of Brakell's patent double-acting steam pumping engines. Each engine shall be capable of lifting 2,500 gallons of sewage per minute to a height of 15 ft., at a speed of forty single strokes per minute, or thereabouts. Each pumping engine shall be able to act independently of the other, and shall form a complete machine on a separate foundation plate, and shall have separate steam and exhaust steam pipes, sewage pipes, and other necessary appliances. The dimensions of the engines shall be as follows: The pump cylinders shall be 30 in. diameter inside, and have a clear depth of 30 in., giving a piston area of 12 in. by 30 in., or 360 square inches. The steam engine cylinder shall be 24 in. diameter inside, and have a clear depth of 12 in., giving a piston area of 9 in. by 12 in., or 108 square inches. The cylinders of both pumps and steam engines and all other portions shall be of best cast iron, clean and sound, both internally and externally, and all steel and wrought iron work shall be free from all specks or hammer marks, and all details to be made in conformity with the drawings and this specification. The cylinders shall be bored perfectly parallel and cylindrical from end to end, and the cylinder covers bored and turned and faced perfectly true. The slide valves of the steam engines shall be of hard cast iron, carefully planed and scraped perfectly true, and the valve faces of the cylinders shall also be similarly planed and scraped. All bolt and stud holes throughout the entire machines shall be drilled. The pistons of the steam engines shall be of best cast iron, with boss shaped to a true circle, the pistons to be also grooved on back side and on the top, and fitted with gun-metal packings, which shall be kept to the faces of the cylinders, so as to insure steam-tight joints, by means of strong bow springs of best steel carefully prepared and fitted. The fixed abutments of the steam engines shall also be grooved and fitted with gun-metal packings and bow springs in like manner. The steam cylinders shall be carefully lagged with polished mahogany lagging secured by means of brass bands and clips. The main shafts of the pumping engines shall be of best Bessemer steel, and all wrought iron work shall be of best hammered scrap iron. The bearings, glands, and stuffing-boxes shall be of best gun-metal, and fitted with self-acting lubricators. The abutments of the pump cylinders shall form the seatings for the pump valves, which shall be made of the best vulcanized india-rubber, working on gun-metal spindles. The pumping engines shall each be complete in themselves, on a strong cast iron foundation frame. Each pump shall have fitted to it the necessary cast iron piping, of 12 in. inside diameter, consisting of a length of straight piping for the suction of 14 ft., or thereabouts, and an elbow pipe and such straight pipes as are necessary for the discharge. Each pump shall also have a suction or foot valve fitted on the bottom of the suction pipes, and all necessary bolts, nuts, washers, and joint rings shall be provided, also all foundation or holding-down bolts for the pumping engines. The whole of the cast iron work shall receive two coats of paint. The whole of the materials and workmanship throughout shall be equal to any supplied by the best engineers. The contractor shall also supply a donkey steam pump, for pumping the feed water for the boiler, together with all suction pipes and valves that are necessary.

The contractor shall provide one portable steam boiler of the locomotive type of 15 nominal horse-power, requiring no brickwork for fixing, of the following dimensions: Total length over all, 11 ft. 8 in.· fire-box, 2 ft. 11 in. by 2 ft. 4½ in. by 3 ft. The barrel of the boiler to be 3 ft. diameter and to be fitted with 34 best tap-welded tubes of 5 in. diameter, and 7 ft. 6 in. long. The fire-box shall be made of the best Lowmoor or Bowling plates, and the shell of best Staffordshire. The fittings shall consist of grate-bars, fire-door, set of firing tools, man hole and mud hole, with covers, stop valve, safety valve, glass water gauge, two gauge cocks, steam pressure gauge, gun-metal blow-off cock, boiler pump, and patent feed or injector. To be also fitted with wrought iron chimney, and mounted on cast iron stands at each end. The steam boiler shall also be fitted with the necessary length of steam piping to the two pumping engines, which shall include two steam valves, with brass valve plugs and seatings, and polished hand wheels; the necessary length of exhaust steam piping to carry the exhaust steam from the pumping engines to the boiler chimney; the necessary length of pipe for the feed water for supplying the boiler shall also be included.

The contractor shall excavate, embank, form, and lay out the irrigation area in the way shown on the plans, for which purpose he shall excavate all land on the area intended to be laid out, and which has a greater elevation than 316 ft. above ordnance datum down to this level at the highest points of the land, and to equivalent lower levels on other portions of the land, so as to bring the whole area properly under the control of the sewage.

The contractor shall lay out the land for the purpose of being irrigated, as is shown on the plan, and as before described. The whole of the area to which the sewage is intended to be applied shall be carefully leveled; the surface material in all cases shall be kept for re-dressing the surface, and, in cases where it is necessary to lower or alter the surface level, the surface materials shall be first removed, and shall be put back again whenever the work is finished. Every uneven or hollow place shall be leveled or filled up, and the land shall be laid out to suit the several modes intended for the distribution of the sewage. The old turf of every field shall be got rid of, either by burning, plowing, digging, harrowing, or by any or all of these operations, but in no case shall it be taken away or be buried. All land in ridges or furrows shall be leveled, and special care shall be taken to guard against settlement. After the land has been leveled it shall be either dug up or plowed up, as shall be found best, and twenty acres of it shall be laid down and sown with Sutton's improved Italian rye grass at the rate of five bushels per acre, and the remaining portion shall be plowed and ridged, and shall in part be sown with mangold wurtzel, and part planted with cabbages, or such other crops as may be directed.

The contractor shall construct all the carriers of their several kinds and sizes as designated on the plan. The carriers marked "O" shall be constructed in concrete of the size shown on the detailed drawings. The carriers marked "A" shall be excavated or made by embanking, as the case may require, and when finished shall be 16 in. deep, 45 in. wide at the top, and 14 in. wide at the bottom. The floor of the trench shall have a fall of one in 2,300. The carriers marked "B" shall be excavated or be made by embanking, as the case may be, and when finished shall be 12 in. deep, 33 in. wide at the top, and 15 in. wide at the bottom, and the floor of the trench shall have a fall of one in 1,600. The carriers marked "C" shall also be excavated or embanked, and shall be 24 in. wide at the top, 7½ in. wide at the bottom, and 9 in. deep. The carriers marked "D" shall be excavated or be embanked, and shall be 6 in. deep, 17 in. wide at top, and 6 in. wide at bottom. The carriers marked "E" shall be 6 in. wide at top and 6 in. deep.

The contractor shall build in concrete or stonework, set in cement, the sluice chambers, as shown in the drawings. The foundation of the side walls of these chambers shall be carried down at least one foot below the level of the floor of the chamber. The floor of the chamber shall be formed in concrete. The contractor, after the completion of the concrete carriers, sluice chambers, or face or retaining walls, shall float the exposed surfaces with a thin coating of Portland cement mortar made in the proportion of one cement to one sand.

The contractor shall excavate the trenches and lay the land drains of the sizes shown by the dotted red lines and figures on the plan of the irrigation and filtration area; all the drains, as far as possible, shall be laid at a depth of 4 ft. The 27 in. outfall drain and open conduit into the river shall be constructed as shown on the drawings.

The position of the sluices is shown on the plan of the irrigation ground, and they shall all be constructed as shown on the drawings. The sluice doors shall be made of good sound red deal, and the sluice frames of oak. All the sluice doors are to be provided with handles at top, worked out of the cross bands. The sluice doors shall all be 1½ in. thickness when finished. The side framing of the sluices shall continue for one foot at least below the level of the sill, and the sluices shall be fixed in position before the concrete work is executed. The contractor shall either paint with three coats, or coat with suitable composition, the sluice frames and doors.

The contractor shall provide 150 elm stop-boards for the small delivery carriers. Each of these boards shall be 20 in. long, 9 in. wide, and 1 in. thick, and shall be worked as shown in the drawings. Each stop-board shall be branded with the letters S L B H.

The contractor shall supply and fit up in the concrete carriers the earthenware flushing blocks, to each of which 8 ft. of 6 in. earthenware pipes shall be laid for the purpose of conducting sewage from the main to the subsidiary carriers. Each of these blocks shall be fitted with a sluice-door with handles.

The contractor shall provide and lay a sufficient length of 12 in. cast iron delivery pipes for conveying the effluent water from each of the pumps into the delivery channel leading into the river Aire, and shall provide all the necessary bends, etc., that may be required, and all nuts, bolts, packing, etc., that may be required for jointing the same.

The contractor shall lay out the special area intended to be used as a filter bed. For this purpose it shall be formed, levelled, and drained, as set forth in the detail drawings. The drains shall all be 6 ft. deep, and the bottom of every trench for a drain for a depth of 3 ft. shall be filled entirely with burnt ballast. The contractor shall remove the surface soil from the site of the proposed filtration area, which soil shall be carefully preserved and be returned into its proper position when the work of forming the filter is completed. The filter shall be formed by having the whole of the ground excavated to a depth of 3 ft.; one half the earth so excavated shall be burnt into ballast and shall afterwards be mixed with the other half, and when mixed shall be returned to its place. The contractor shall form the puddle walls for dividing the filtering area, and all the drains and culverts for securing the drainage of the same. The filter shall be ridged and sown with mangolds.

The contractor shall receive payment on account of his contract in monthly instalments on the certificate of Mr. Baldwin Latham, the engineer, at the rate of 90 (£90) per cent. on the value of the works completed and in progress each month. One moiety of the balance shall be paid three months after the date of the completion of the work as certified by the engineer, and the other moiety six months after the date of the completion of the works, provided the engineer then certifies that the whole of the works are in perfect repair, order, and condition. The whole of the payments shall, however, be subject to any charges or deduction to which the contractor may be liable under the contract.

SANITARY SCIENCE.

MR. ALFRED HAVILAND, M.R.C.S., read, at a meeting of the London Social Science Association, an interesting paper on "Physical Geography in relation to Sanitary Science, and the Valley System in relation to Disease." He observed that in inhabited valleys there was often to be found much rheumatism, which frequently ended in heart disease. The cause of that was that valleys did not get sufficient fresh air, which was so important for vigorous life. The winds blew over them, not through them; and consequently emanations from the soil hung about, instead of being dispersed. As a rule, the cottages of the poor and the mansions of the rich were found in the trough of valleys, and it was impossible to calculate how many an old family had been deprived of the most promising of their scions by adhesion to an ill-sited family mansion as a home. A discussion followed, in which Dr. B. W. Richardson took part, testifying to the great value to medical men of Mr. Haviland's maps, as they enabled them to learn whether the disease was the effect of meteorological influences. He thought that at least twenty-five or thirty diseases might be traced to that source; and among them he would place croup, influenza, erysipelas, scrofula, remittent fever, rheumatism, phthisis, bronchitis, pleurisy, lung diseases, fistula, calculus, and possibly some malformations. That is a serious list, and the subject deserves much consideration.

[NEW REMEDIES.]

PRESCRIPTIONS AND FORMULÆ.

COSMOLINE CREAM. (E. J. Davidson, in *Amer. Jour. Phar.*)

Cosmolin	24 troy ounces.
White wax	
Spermaceti, āā	12 "
Glycerin	3 fluid ounces.
Oil of rose geranium	1 fluid drachm.

Melt the wax and spermaceti, add the cosmolin; then stir until nearly cold; add the glycerin and oil, and stir until cold.

MISTURA ANTISPASMODICA (Potion antispasmodique opiacée), *concentrated.*

℞ Spiritus menthæ pip	1 gramme.
Alcoholis	6 "
Vini opii	10 "
Aetheris	30 "

M. Ten drops of this mixture, added to a tablespoonful of water, represent 15 grammes, or one tablespoonful of the ordinary antispasmodic mixture. The concentrated solution is proposed for the purpose of facilitating a supply to be carried in the pocket.

ELIXIR OF MONOBROMATED CAMPHOR. (Munday.)

Monobromated camphor	3 parts.
Alcohol 90 %	120 "
Orange-flower water	80 "
Glycerin	100 "

Mix the alcohol and glycerin, dissolve the monobromated camphor by the use of a gentle heat, and add the orange-flower water. This solution contains 1% of monobromated camphor.

EFFERVESCING CARBONATE OF IRON. (Dr. T. Skinner.)

Tartaric acid	24 parts.
Sodium bicarb	40 "
Iron sulphate (proto)	10 "
Sugar, powd	14 "
Citric acid	2 "

Mix the finely powdered dry materials as follows: First, the sulphate of iron with the sugar and part of the tartaric acid; secondly, the citric acid with the remainder of the tartaric acid and the bicarbonate. Stir the two mixtures together, and unite by sifting. Finally, granulate in open metal vessel over a water-bath.—*Pharmacist.*

EMOLLIENT GLYCERINE LOTION.

Take of mucilage of quince seeds, 1 fluid ounce; glycerin, 1 fluid ounce; orange flower water, 6 fluid ounces. Make a lotion.—*Pharmacist.*

PODOPHYLLIN PILLS. ("Castor Oil Pills.")

Resin podophylli	gr. iii.
Extr. hyoscyami	gr. iii.
Saponis	gr. ivss.
Syrupi	gtt. vi.

M. Make 12 pills.

STANDARD FORMULÆ FOR CERTAIN NEW PREPARATIONS.

The Société de Pharmacie of Paris some time ago appointed a commission, consisting of Messrs. Schaeufèle (president), Baudrimont, Gobley, Marais, and Petit (reporter), to prepare standard formulæ for certain new preparations, from whose report we select the following:

1. *Salicylic Acid*, $C_7H_6O_3$.—A concentrated solution of commercial caustic soda is exactly neutralized with crystallized phenol, the liquid is evaporated in an iron kettle, and constantly stirred, until a pulverulent mass remains. This is sodium phenate, which is very hygroscopic, and must be kept, unless used immediately, in hermetically sealed vessels. This salt is introduced into a tubulated glass retort placed into an oil bath, and as soon as the temperature has reached 100° C., a current of dry carbonate acid gas is passed through the contents of the retort. The temperature is gradually allowed during 3 or 4 hours to rise to 180° C. It requires some time before phenol begins to distil over, which is obtained in considerable quantity. Finally, the heat is raised to 220° C., and lastly to 250° C. The operation is finished as soon as the current of carbonic acid gas, at this temperature, carries over no more traces of phenol. The retort then contains only brown basic sodium salicylate. This is dissolved in water, and decomposed by hydrochloric acid. The crude salicylic acid is transferred to a filter, drained and washed, and once or twice recrystallized from boiling water. It may be obtained very pure by sublimation in brilliant needles.*

2. *Thymic Acid*, $C_{10}H_{14}O$.—Add an aqueous solution of potassa or soda (1 : 10) to oil of thyme, and agitate repeatedly to facilitate combination. Thymic acid or thymol enters into solution, while thymene, the accompanying hydrocarbon, remains unacted upon. The solution is filtered and treated with an acid, hydrochloric acid for instance, which liberates the thymic acid. The crude acid is washed with water, and, after drying, distilled. Thymic acid thus prepared is liquid, but it may be obtained crystalline by exposing oil of thyme for some time to the cold. It is but little soluble in water, but very soluble in alcohol. It is strongly caustic.

3. *Crystallized Aconitine*, $C_{27}H_{40}NO_{10}$.—Exhaust the powdered root of *Aconitium ferox* with concentrated alcohol, to which $\frac{1}{100}$ part of tartaric acid has been added. The solution is distilled at a moderate heat, out of contact with air, to recover the alcohol. The residue is taken up by water, which leaves all fatty or resinous substances behind. The watery solution, which contains the aconitine as tartarate, is shaken with ether, which removes coloring matters, then mixed with alkaline bicarbonate, until effervescence ceases, whereby the alkaloid is set free. The solution is again shaken with ether, which dissolves out the alkaloid, and leaves the latter behind on evaporation. To obtain it in crystals, some petroleum ether should be added to the ethereal solution. It forms colorless or hexagonal rhombic tables, soluble in alcohol, benzine, and chloroform; insoluble in petroleum oils and glycerine.

4. *Ammonium Bromide*, NH_4Br.—Bromine is added very slowly to water of ammonia, under constant stirring, and until the liquid shows a faint excess of bromine. A few drops of ammonia are then added to overcome this excess, and the solution is evaporated to the point of crystallization. The salt appears in long colorless prisms, volatile without decomposition, and very soluble in water. Its watery solution must not become colored on addition of a few drops of concentrated hydrochloric acid, and on adding to it a small quantity of starch paste and slightly yellowish nitric acid, no blue or violet color must make its appearance.

5. *Apomorphia*, $C_{17}H_{17}NO_2$.—Introduce 1 part of pure morphia and 20 parts of pure hydrochloric acid into a strong glass tube, closed at one end, and capable of holding at least 15 times the quantity. Close the open end of the tube by fusion, and insert it into a cast iron tube closed at one end with a screw plug. Place the whole apparatus into an oil bath, and heat for 3 hours to between 140° and 150° C. After cooling, the tube may be opened without risk, for there is no pressure of gas inside. The solution is poured out, diluted with water, neutralized with sodium bicarbonate, and, finally, an excess of this salt added, which throws down apomorphia and any remaining unaltered morphia. The supernatant liquid having been decanted, the precipitate is taken up or exhausted by ether or chloroform, which only dissolve the apomorphia. To the ethereal or chloroformic solution enough hydrochloric acid is added to neutralize the base, which separates now from the solution spontaneously and settles upon the walls of the vessel. These crystals are rapidly washed with cold water, and purified by crystallization from boiling water. The pure alkaloid may be obtained by precipitating the solution of the muriate with sodium bicarbonate; a white precipitate is obtained, which rapidly turns green in the air. It must be quickly washed and dried. Its solution soon turns green and spoils, but sugar or exclusion of air prevent the change.

6. *Theïne* or *Caffeïne*, $C_8H_{10}N_4O_2,H_2O$.—Exhaust good green or black tea with boiling water to obtain a concentrated solution, which is precipitated by a slight excess of basic lead acetate. Add to the magma a small quantity of ammonia, filter and separate the excess of lead in the liquid by a current of sulphydric acid gas. Filter again, and evaporate slowly. On cooling an abundant crop of nearly pure crystals of caffeine is deposited. The mother liquor yields more crystals on further evaporation.

7. *Bibasic Calcium Phosphate*, $CaHPO_4.3H_2O$.—Dissolve 608 parts of crystallized calcium chloride in 1,000 parts of distilled water, and add to it gradually a solution of 1,000 parts of crystallized sodium phosphate in 10,000 parts of water. Let the precipitate subside, wash five or six times by decantation, with about 10,000 parts of water each time. Transfer the magma to a muslin-strainer, and allow it to drain. As soon as its consistence permits, cut it into pieces, which should be exposed to the air upon blotting-paper. It dries rapidly by spontaneous evaporation, and forms a very white and light salt.

* Complaints have been made of the sublimed acid being not sufficiently pure. Dialysed salicylic acid has been placed upon the market by E. Schering, and is no doubt the purest form in which it can be used.

8. *Syrup of Calcium Chlorhydrophosphate.*

Calcium phosphate, bibasic	12·5 parts.
Chlorhydric acid, pure (only just enough or about)	8 "
Distilled water	340 "
White sugar, in coarse powder	630 "
Essence of lemons	10 "

Mix the calcium phosphate intimately with the water, add the chlorhydric acid in just sufficient quantity to dissolve the lime salt, then add the sugar, and dissolve cold, or with a *very* gentle heat. Filter, and add the essence of lemons to the cold syrup.

9. *Syrup of Calcium Lactophosphate.*

Calcium phosphate, bibasic	12·5 parts.
Lactic acid, concentrated (only just enough or about)	14 "
Distilled water	340 "
White sugar, in coarse powder	630 "
Essence of lemons	10 "

Mix the calcium phosphate intimately with the water, add the lactic acid in just sufficient quantity to dissolve the lime salt, then add the sugar, and dissolve cold or with a *very* gentle heat.

10. *Syrup of Acid Calcium Phosphate.*—This is prepared exactly like the preceding two syrups, substituting a sufficient quantity of medicinal phosphoric acid, spec. grav. 1·45, or about 18 grammes.

11. *Glycerole of Calcium Saccharate.*

Burnt lime, clean and white	80 grammes.
Sugar, powdered	160 "
Glycerin	160 "
Water, q. s. to make	1 litre.

To the lime and sugar add gradually, and in small portions, 700 grammes of water. After 24 hours of contact, filter, add the glycerin and sufficient water to make 1 litre. This glycerole is used for preparing the following:

12. *Liniment of Calcium Saccharate.*

Olive oil	200 parts.
Glycerole of calcium saccharate	100 "

Mix.—*Répert. de Pharm.*, 1877, No. 2, 3.

SOLUTION OF BROMIDE OF ARSENIC.—(R., Richmond, Ind.) The peculiar solution which goes by the above name, is that introduced many years ago by Dr Clemens, of Frankfort on the Main, and which Dorvault, in his *Officine*, calls "Liqueur Clémens," or "Liqueur à l'arsenite de bromure de potassium." It is intended as a substitute for Fowler's solution. Its formula is as follows:

Arsenious acid	1 part	by weight.
Potassium carbonate	1 "	
Bromine	2 "	
Distilled water, to make	93 "	

Boil the carbonate and the acid with most of the water, until they are dissolved; when cold, add the bromine and enough water to make up the bulk to 93 parts.

Age is supposed to improve this mixture, as the bromine gradually enters into combination. The dose of the solution is from 1 to 4 drops in waters, once or twice daily.

ANALYSIS OF RIDGE'S FOOD.—The *Medical Examiner* gives the following analysis of Dr. Ridge's Food:

Moisture	9·31
Oil (fat)	·92
Nitrogenous (or flesh-forming) matter	5·25
Starch, sugar, and digestible fibre	83·63
Cellulose	traces
Ash	·88
	100·00

AMMONIATED TINCTURE OF GUAIACUM IN INFLAMED THROATS.

Dr. Garner recommended some time since (*Canada Lancet*, July, 1876) the employment of ammoniated tincture of guaiacum in inflammation of the throat whether acute or chronic The remedy, he says, seems to be totally unknown to some practitioners, and wholly ignored by others. He uses the remedy with almost invariable success in cases of chronic hoarseness, employing it in the form of a gargle. In the first stage of quinsy its action is astonishing In cases of inflamed tonsils or sore throat, when produced by, or accompanying, measles, scarlatina, cynanche, parotiditis, and croup, he uses the pure tincture by means of a sponge-brobang. His formula for a gargle is as follows:

GARGLE FOR SORE THROAT.

℞. Tinct. guaiaci ammon	ʒ iij.
Liquor. potassæ	ʒ ij.
Tinct. opii	ʒ ij.
Aq. cinnamomi	ad f. ℥ viij.

HOW TO CURE A BAD COLD.

Wharton (*Virgin. Med. Monthly*) recommends carbonate of ammonia in full and often repeated doses: 10 grains, in mucilage, every hour or two hours, for one or two days in severe cases. With proper attention to other hygienic means the patient will soon recover from the severest cold without the liability to relapse which follows the employment of sweating medicines.

DIGESTIVE PASTILLES OF BORIVENT.

Bismuth subnitrate	20 parts.
Calcium phosphate	30 "
Sodium bicarbonate	10 "
Magnesium carbonate	200 "
Iron carbonate	50 "
Sugar	1000 "

Flavor with essence of peppermint, anise, or orange-flowers. Make into pastilles of 1 gramme each, of which 3 to 12 may be taken daily.

"SULPHUR PILLS."

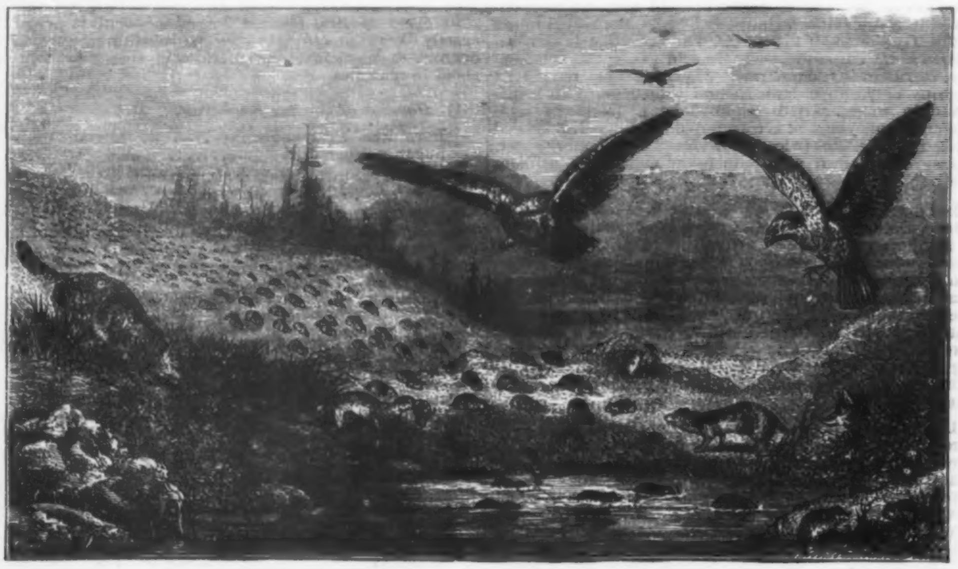
Potassii sulphureti.	
Pulveris jalapæ,	
Saponis	āā ʒ i.
Extr. taraxaci	q. s.

Make 120 pills.

THE NORWEGIAN LEMMING AND ITS MIGRATIONS.

By W. DUPPA CROTCH, M.A., F.L.S.

AMONG the many marvellous stories which are told of the Norwegian Lemming (*Myodes lemmus*, Linn.) there is one which seems so directly to point to a lost page in the history of the world that it is worth a consideration which it appears hitherto to have escaped. I allude to the remarkable fact that every member of the vast swarms which periodically alm st devastate Norway perishes voluntarily, or at least instinctively, in the ocean. But as among my readers some may not be familiar with the lemming, a brief description of the animal itself will not be out of place. It is a vole, like our short-tailed field mouse, very variable in size and color, but the figures (Fig. 1.), which are about half the natural size, will be found to resemble the majority in the latter respect. The claws, especially on the fore foot, are strong and curved, the tail is very short, the ears scarcely visible, and the beadlike black eyes seem always to notice objects above them rather than those in any other direction. During the summer these animals form their nests under stones, usually betraying their habitations by the very care which they take to keep them sweet and clean. In winter, however, they form long galleries through the turf and under the snow in search of their food, which is exclusively vegetable; and it is at this time that those ravages are caused which have led the Norwegians in former times to institute a special form of prayer against their invasions. There are several species of lemming, easily recognizable, and with well-marked geographical range; but it is to the Scandinavian species only that the following old description applies: "It lives on the shoots of the dwarf birch, reindeer lichens, and other mosses; it hisses and bites; in winter it runs under the snow; and about every tenth year, especially before an extremely severe winter, the whole army of animals, in the autumn and at night, migrates in a direct line." According to Olaus Magnus they fall from the clouds, and Pennant narrates that they "descend from the Kolen, marching in parallel lines three feet apart; they traverse Nordland and Finmark, cross lakes and rivers, and gnaw through hay and cornstalks rather than go round. They infect the ground, and the cattle perish which taste of the grass they have touched: nothing stops them, neither fire, torrents, lakes, nor morasses. The greatest rock gives them but a slight check; they go round it, and then resume their march directly without the least division. If they meet a peasant they persist in their course, and jump as high as his knees in defence of their progress. They are so fierce as to lay hold of a stick and suffer themselves to be swung about before they quit their hold. If struck they turn about, and bite, and will make a noise like a dog. Foxes, lynxes, and ermines follow them in great numbers, and at length they perish, either through want of food or by destroying one another, or in some great water, or in the sea. They are the dread of the country, and in former times spiritual weapons were exerted against them; the priest exorcised them, and had a long form of prayer to arrest the evil. Happily it does not occur frequently—once or twice only in twenty years. It seems like a vast colony of emigrants from a nation overstocked, a discharge of animals from the northern hive which once poured forth its myriads of human beings upon Southern Europe. They do not form any magazine for winter provision; by which improvidence, it seems, they are compelled to make their summer migration in certain years, urged by hunger. They are not poisonous, as vulgarly reported, for they are often eaten by the Laplanders, who compare their flesh to that of squirrels."

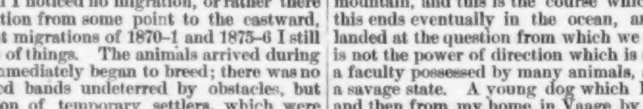


NORWEGIAN LEMMINGS IN MIGRATION.

M. Guyon disposes of the theory that these migrations are influenced by *approaching* severe weather, since the one witnessed by himself took place in the spring; also the superabundance of food during the previous autumn precluded all idea of starvation. He, therefore, adopts a third view, that excessive multiplication in certain years necessitates emigration, and that this follows a descending course, like the mountain streams, till at length the ocean is reached. Mr. R. Collett, a Norwegian naturalist, writes that in November, 1868, a ship sailed for fifteen hours through a swarm of lemmings, which extended as far over the Trondhjems-Fjord as the eye could reach.

I will now relate my own experience of the lemming during three migrations in Norway, and in a state of captivity in England. The situation of Heimdalen, where I reside during the summer months, is peculiarly well suited for observation of their migrations, lying as it does at an elevation of 3,000 feet, and immediately under the highest mountains in Scandinavia, and yet, excepting during migration, I have never seen or been able to procure a specimen. It was in the autumn of 1867 that I first heard the peculiar cry of the lemming, guided by which I soon found the pretty animal backed up by a stone, against which it incessantly jerked its body in passionate leaps of rage, all the while uttering a shrill note of defiance. The black, beadlike eyes seemed starting from their sockets, and the teeth shone white in the sunlight. I hastily snatched at the savage little creature, but it sprang completely round, fastened its teeth sharply in my hand, and taking advantage of my surprise, escaped under a large stone, whence I could not dislodge it. A Norwegian friend who accompanied me by no means shared my feelings of satisfaction at the sight of a lemming. "We shall have a severe winter and no grass next spring owing to those children of Satan!" was his comment on the event. However, it was many a month before I saw another; then, on lifting a flat stone, I found six in a nest of dried grass, blind, and apparently but just born. In a few days the whole fjeld became swarming with these pretty voles; at the same time white and blue foxes made their appearance, and snowy owls and many species of hawks became abundant. My dogs, too, were annoyed by the rash courage of the new comers, which would jump at their noses even when slowly drawing on game, so that they never spared a lemming, though they never ate them till last year, when I observed that they would eat their heads only, rejecting the body, although they devoured the common field mouse to the end of his tail. As the season advanced and snow covered the ground, the footprints and headless carcasses told plainly how hard it must be for a lemming to preserve its life, although there can be no doubt that its inherent pugnacity is its worst enemy. In this country we fail to conceive how much active life goes on beneath the snow, which in more northern latitudes forms a warm roof to numerous birds, quadrupeds, and insects, which are thus enabled to secure an otherwise impossible sustenance. At the same time, as I have already noticed, a fearful struggle for existence is carried on during the long autumnal nights before the snow has become a protection rather than a new source of danger to all save predaceous animals. It was a curious sight, when the whole visible landscape was of an unbroken whiteness, to see a dark form suddenly spring from the surface and scurry over the snow, and again vanish. I found that some of the holes by means of which this feat was executed were, at least, five feet in depth, yet even here was no safety, for the reindeer often kill the lemmings by stamping on them, though I do not believe their bodies are ever eaten.

During the autumn I noticed no migration, or rather there was only an immigration from some point to the eastward, and in the subsequent migrations of 1870–1 and 1875–6 I still found the same state of things. The animals arrived during early autumn, and immediately began to breed; there was no procession, no serried bands undeterred by obstacles, but there was an invasion of temporary settlers, which were speedily shut out from human view by the snow, and it was not till the following summer that the army, reinforced by five or six generations, went out to perish like the hosts of Pharaoh. On calm mornings my lake, which is a mile in width, was often thickly studded with swimming lemmings, every head pointing westward; but I observed that when my boat came near enough to frighten them they would lose all idea of direction and frequently swim back to the bank they had left. When the least wind ruffled the water every swimmer was drowned, and never did frailer barks tempt a more treacherous sea, as the wind swept daily down the valley, and wrecked all who were then afloat. It was impossible not to feel pity for these self-haunted fugitives. A mere cloud passing over the sun affrighted them; the approach of horse, cow, dog, or man, alike roused their impotent anger, and their little bodies were convulsively pressed against the never-failing stone of vantage (see Fig. 1), whilst they uttered cries of rage. I collected 500 skins, with the idea of making a rug, but was surprised that a portion of the rump was nearly always denuded of hair, and it was long before I discovered that this was caused by the habit of nervously backing up against a stone, of which I have just spoken. As this action is excited by every appearance of an enemy, it seems surprising that a natural callosity should not take the place of so constant a lesion; possibly, however, the time during which this lesion occurs is too short to cause constitutional change.



Plan of Heimdalen drawn to scale, in which the course of the Lemmings, indicated by the arrows, is seen to cross Lake Heimdalsvand and the swift river Leirungen, both of which might be avoided by a slight detour. The river is of glacier origin, very cold and very rapid.

Early in the autumn, and just a year after their arrival at Heimdalen, the western migration commenced anew. Every morning I found swarms of lemmings swimming the lake diagonally, instead of diverging from their course so as to go round it, and mounting the steep slopes of Heimdals-hö (Figs. 2 and 3), on their way to the coast, where the harassed crowd, thinned by the unceasing attacks of the wolf, the fox, and the dog, and even the reindeer, pursued by eagle, hawk, and owl, (see Pl. IV.), and never spared by man himself, yet still a vast multitude plunges into the Atlantic Ocean on the first calm day, and perishes with its front still pointing westward. No faint heart lingers on the way, and no survivor returns to the mountains.

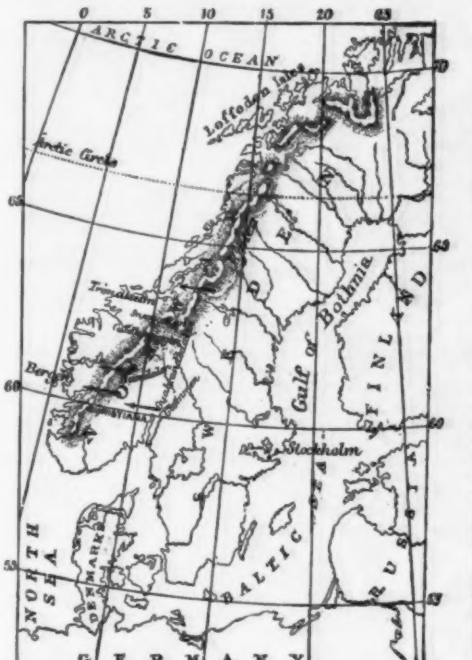
There appears to have been a difficulty in keeping these restless creatures in captivity, both because they escape through incredibly small apertures (generally however, dying from internal injuries thus caused), and because they will gnaw through a stout wooden cage in one night, and devote every spare moment to this one purpose, with a pertinacity worthy of Baron Trenck. At all events, few have been brought alive to this country, and none have survived. At present (February, 1877) I have one which I have preserved since September last, defeating his attempts at escape by lining the cage with tin, and allowing him a plentiful supply of fresh water, in which he is always dabbling. With the approach of winter all his attempts to escape ceased, and I now always take the little stranger for an airing in my closed hands, whilst his bed is being made and his room cleaned out. He seems to like this, but after a few minutes a gentle nibble at my finger testifies to his impatience, and if this be not attended to the biting progresses in a crescendo scale until it becomes unbearable, although it has never under these circumstances drawn blood. My little prisoner shows few other signs of tameness, but the fits of jumping, biting, and snarling rage have almost ceased. I expect, however, that with the return of spring the migratory impulse will be renewed, and that he will kill himself against the wires of his cage, like a swallow.

The reader is now in a position to consider the three questions raised by the above facts, and those questions are as follows: 1. Whence do the lemmings come? 2. Whither do they go? 3. Why do they migrate at all? With regard to the first, no one has yet supplied an answer. They certainly do not exist in my neighborhood during the intervals of migration; and the Kjolen range was probably selected as their habitat, not because it was proved to be so, but because so little is known about it at all. The answer to the second question is certain: they go to the sea. Those on the east of the backbone of Norway go to the Gulf of Bothnia, and those on the west to the Atlantic Ocean (Fig. 4), and out of 18 migrations which have been investigated, one only, and that very doubtful, is reported to have been directed southward. The question as to the cause of these migrations remains, and is a very difficult one to answer. We have been told that the fore-knowledge of approaching severe weather predetermines the exodus: my experience, however, contradicts this, and it may be dismissed as merely a popular superstition. Unusual reproduction and consequent deficiency of food is a more plausible theory, but I have always noticed that, just as with the swallow, a few individuals have preceded the main body, and that during the first autumn the numbers are never large, but after a winter spent beneath the snow they begin to breed with the first days of summer, and thus develop the extraordinary multitude, which is, as it well may be, the astonishment and terror of the country. It appears, then, that excessive reproduction is rather the result than the cause of migration. It has also been suggested that the course taken by the lemmings follow the natural declivities of the country, but a reference to the maps will show that in that case nearly all the Norwegian migrations should take a southerly route, which is by no means the case. On the contrary, westward at Heimdal means across a rapid river, over a wide lake, and up a steep, rocky, and snowy mountain, and this is the course which is followed. Now, this ends eventually in the ocean, and thus we are again landed at the question from which we set out. After all, it is not the power of direction which is so remarkable: this is a faculty possessed by many animals, and by man himself in a savage state. A young dog which I took from England, and then from my home in Vaage by a path to Heimdalen, a distance of 46 miles, ran back the next morning by a direct route of his own, crossing three rapid rivers, and much snow, and accomplishing the distance in six hours, without the vestige of a path. This same dog afterwards repeated the feat, but followed the path, and took two days in reaching his destination, hindered and not aided, as I believe, by his experience. Herr Palmen, indeed, says "experience guides migration, and the older migrants guide the younger," like one of Mr. Cook's personally conducted tours. This obviously cannot be the case with the lemmings.

It is now generally admitted that instinct is merely inherited experience, and is therefore primarily calculated to benefit the species, unless indeed circumstances have changed meanwhile more rapidly than the structures to which the phenomena of instinct are due. Now, the lemmings during their wanderings pass through a land of milk and honey, where, if their instincts could be appeased, they might well take up a permanent abode, and yet they pass on, whilst their congener, the field-vole, remains in quiet possession of

the quarters from which he was temporarily ousted. It is indeed almost as strange a sight to see the holes, the deeply grooved runs, and the heaps of refuse of these restless creatures, which have passed away but yesterday, as it is to see the fjelds suddenly become alive with a new and boisterous tenant, who, like another Ishmael, has the hand of all men against him.

Now, if we compare the migration of the lemmings with that of our more familiar swallows, we find that the latter obviously seek a more genial climate and more abundant food, returning to us as surely as summer itself; nor do they ever, so far as I know, breed on their passage. The swifts, which stay but a short time with us, remain in Norway barely long enough to rear their young before returning to Africa. It is difficult, in fact, to find a parallel case to that of the lemmings: the nearest approach, perhaps, is afforded by the strange immigration of Pallas' sand-grouse in 1863, when a species, whose home is on the Tartar Steppes, journeyed on in considerable numbers to the most western shore of Europe, and very probably many perished, like the lemmings, in the waves of the Atlantic. But to revert to the swallows, which annually desert Europe to visit Africa. Let us suppose that these birds were partial migrants only—that is, that a remnant remained with us after the departure of the main body—and further suppose that the continent of Africa were to become submerged, would not many generations of swallows still follow their inherited migratory instincts, and seek the land of their ancestors through the new waste of waters, whilst the remaining stock, unimpeded by competition, would sooner or later, according to the seasons, recruit the ranks for a new exodus? It appears quite as probable that the impetus of migration towards this lost continent should be retained as that a dog should turn around before lying down on a rug, merely because his ancestors found it necessary thus to hollow out a couch in the long grass.



Outline map of Scandinavia. The two main valleys, Gudbrandsdalen, and the valley of the Glommen, run nearly north and south. The course of the Lemmings crosses there at right angles, as indicated by the arrows.

Well, then, is it probable that land could have existed where now the broad Atlantic rolls? All tradition says so: old Egyptian records speak of Atlantis, as Strabo and others have told us. The Sahara itself is the sand of an ancient sea, and the shells which are found upon its surface prove that no longer ago than the Miocene period a sea rolled over what now is a desert. The voyage of the "Challenger" has proved the existence of three long ridges in the Atlantic Ocean, one extending for more than three thousand miles; and lateral spurs may, by connecting these ridges, account for the marvelous similarity in the fauna of all the Atlantic Islands. However, I do not suppose that the lemmings ever went so far south, though they are found as fossils in England; but it is a remarkable fact that whilst the soundings off Norway are comparatively shallow for many miles, we find a narrow, but deep, channel near Iceland, which, probably, has prevented the lemming from becoming indigenous there, although an American species was found in Greenland during the late Arctic Expedition. If, as is probable, the Gulf Stream formerly followed this deep channel, its beneficent influence would only extend a few miles from the coast, which would have reached to a great distance beyond the present shores of Norway, and thus the lemmings would have acquired the habit of traveling westward in search of better climate and more abundant food; and as little by little the ocean encroached on the land the same advantages would still be attained. And thus, too, we find an explanation of the fate which befalls the adventurous wanderers; for we have already seen that no lake deters them, and that they frequently cross the fjords, or arms of the sea, in safety. No doubt, therefore, they commit themselves to the Atlantic in the belief that it is as passable as those lakes and fjords which they have already successfully dared, and that beyond its waves lies a land which they are never destined to reach.

The submerged continent of Lemuria, in what is now the Indian Ocean, is considered to afford an explanation of many difficulties in the distribution of organic life, and I think the existence of a Miocene Atlantis will be found to have a strong elucidative bearing on subjects of greater interest than the migration of the lemming. At all events, if it can be shown that land existed in former ages where the North Atlantic now rolls, not only is a motive found for these apparently suicidal migrations, but also a strong collateral proof that what we call instincts are but the blind and, sometimes, even prejudicial inheritance of previously acquired experience.

DEMODEX FOLLICULORUM.

WHETHER Butler's reference to the "maggot in cheesemonger's nose" is to be taken as evidence that the philosophers of his day had any knowledge of the existence of the curious parasite in the follicles of the human skin to which the above name has been given, is a question that we may leave to the learned in such matters, who may at the same time settle whether cheesemongers are more subject than other men to the peculiar pimples which betray the presence of the parasite. Our first definite knowledge of it is due to Dr. Simon, of Berlin, who discovered it in 1842, by the assistance of Erichson recognized its affinity to the mites (the group to which the itch-parasite also belongs), and described it pretty fully under the name of *Acarus folliculorum*. Professor Owen, in 1843, founded a new genus for the reception of the parasite, and called it *Demodex;* Erasmus Wilson, who regarded it as a worm, named its genus *Entozoon;* M. Paul Gervais, in ignorance of Professor Owen's name, gave it the generic name of *Simonea;* and M. Miescher, changing both names, christened it *Macrogaster platypus*. M. P. Mégnin, a well-known student of the Acarina, has just published (in the *Journal de l'Anatomie et de la Physiologie*, 1877, No. 2) a long and interesting memoir upon *Demodex folliculorum*, containing a history of our knowledge of the animal, a discussion of its zoological affinities, a full description of its structure, and an account of its development and habits. Like its discoverer, and most of the zoologists who have described it, he refers it to the order of mites (*Acarina*), and, following M. Paul Gervais, he regards it as forming a distinct family (*Demodicidæ*) in that order, nearly related to the Bear Animalcules (*Arctisca* or *Tardigrada*), so well known to all microscopists, on account of their wonderful faculty of coming to life again after desiccation.

These creatures are minute, somewhat worm-like parasites, from $\frac{1}{125}$ to about $\frac{1}{75}$ inch in length, having a more or less oval cephalothorax, bearing in front a sort of rostrum composed of mandibles, maxillæ, palpi, and ligula, and along its sides four pairs of short, three-jointed feet, each furnished with a pair of blunt claws. Behind this part comes a thinner, finely-ringed abdomen, variable in length, but usually longer than the cephalothorax. The little animals are found in the sebaceous and hair follicles of the skin in man and some animals. They are said by M. Megnin to be viviparous, the females producing small footless, contractile larvæ, without any mouth organs; these, shortly after their birth, acquire three pairs of conical tubercles; which serve them as feet for creeping about. A change of skin converts these larvæ into pupæ of similar form, but having four pairs of papilliform feet, and showing traces of the rostrum. After a second change the perfect *Demodex* is produced, but still without the sexual organs, which make their appearance subsequently. M. Mégnin distinguishes three, if not four, forms of these parasites, which, however, he prefers to regard for the present as varieties of a single species, *Demodex folliculorum*. The commonest of these appears to be that of the bug (var. *caninus*), which inhabits the hair-follicles of all parts of the body of that animal. A smaller variety (*cati*) is found almost solely in the sebaceous glands of the ear of the cat; and a larger one (var. *hominis*) in the follicles of the human face. M. Simon also met with similar parasites in the glands of the margin of the eyelids in sheep (var. *ovis*), but no other writer has ever seen them there. In the dog the presence of these parasites, which occur in great numbers together in the hair follicles, produces a regular skin disease, or mange, but this does not appear to be transmissible to the human subject.

INTELLIGENCE OF ANTS.

SIR JOHN LUBBOCK has communicated to the Linnean Society a fourth part of his "Contributions on the Habits of Ants, Bees, and Wasps," in which he describes the results of numerous ingenious experiments made to test the intelligence of various species of the first-named group. Individuals of *Lasius niger*, engaged in fetching larvæ out of a small glass cell, in which they passed over a somewhat complicated bridge, were at once stopped in their proceedings by the interposition of a small gap of only $\frac{1}{3}$ inch; they had not sufficient intelligence to drop this short distance, unless, indeed, they were deterred by prudential considerations as to the possibility of getting back, nor did those below adopt the apparently easy method of crowding upon each other to the required height to re-establish the broken communication. As an example of conscientious industry, Sir John cited the case of an individual ant, which he was in the habit of shutting up in a bottle before leaving home for the day; the little prisoner when released immediately commenced work, and even a week's imprisonment had no effect upon its zeal. From some experiments, it appears that ants when in difficulties in sight of their companions are by no means always assisted or relieved, and this is especially the case when the charms of a store of honey or other food come into competition with the promptings of the benevolent instincts. Individuals under the influence of chloroform were generally passed without notice, but sometimes even their friends would push them out of the way; the general practice was to let friends lie, but to drop strangers over the edge of the board. Intoxicated ants appeared to be a puzzle to their friends, who, however, generally picked them up and carried them into the nest; but strangers in the same condition were not so kindly used, they were thrown into the water and drowned. Sometimes mistakes occurred, strangers were carried into the nest, and friends thrown into the water; no attempts were made to save the latter, but the strangers were generally detected and ignominiously dragged out of the nest again. From various experiments, it appeared that the ants of an entire nest know and recognize each other; indeed, even after a year's absence, old companions are recognized and amicably received, whereas strangers are almost invariably attacked and maltreated, even when mixed with old friends. In this respect, however, different species show differences of character; *Lasius flavus* behaves as above described, but *Formica fusca* is much milder and more courteous in its demeanor toward strangers. Some of the experiments seem to show that the sense of sight is not very acute in certain species of ants. Thus, food was placed a few inches from the nest on a glass slip, the straight road to and from which was soon learned, but when the food was shifted only a short distance from its original position, the same individual ants wandered about in a circuitous path for several minutes, and sometimes for half an hour, before discovering the new locality of the food. Sir John Lubbock confirms the statements of former writers as to slavery being a regular institution with some genera of ants, and states that the Amazon ants (*Polyergus rufescens*) absolutely require a slave attendant to clean and feed them. Some of his experiments seemed to prove that these aristocratic ants would rather die than help themselves. The author also referred to certain parasites on ants and in ants' nests.

ARTIFICIAL BUTTER.

FARMERS are needlessly alarmed at the rapid strides made in the manufacture of artificial butter, and at the wonderfully increasing sales of this new element of competition with the products of the dairy. Undoubtedly this cheaper article is by its very excellence crowding out the use of large quantities of inferior butter, and herein lies the lesson to be learned by careless, heedless dairymen. First-class butter, of genuine good quality, is likely to be sold at a better price than ever, for the world's population is increasing, as also is the number of people who prefer the best butter the market affords.

Dairymen must learn their business more thoroughly; they must not let foolish pride or prejudice blind their eyes to the fact that if their butter only finds a market at the lowest price it is not on account of its inferior quality. It is an exceedingly difficult and thankless task to atttempt to convince any farmer that his wife ever makes a poor tub of butter, but the stern logic of facts is unanswerable. That hundreds of tons of poor butter finds its way to an unsatisfactory market year after year is apparent to all. A general diffusion of knowledge concerning the proper methods to pursue, and an honest effort on the part of all producers to improve the quality of the butter, would result in a vast addition to the dairy revenue of America.

There is no mystery about the manufacture of oleomargarine. Animal or caul fat, ox suet, is the basis. On its arrival at the factory the fat is thrown into vats of clean, pure water; carefully washed, examined, and doubtful portions rejected; the clean-washed fat is then fed into chopping machines, and when reduced to a finely hashed and pulpy condition is run into large steam jacket kettles, where, with a uniform temperature of 120°, it is rendered in about two and one-half hours; thence drawn into smaller kettles, where membrane and other impurities are deposited; while still hot it is run off and finally moulded in flat cakes, each of which is wrapped in cloth and placed in layers in a hydraulic press, where under a heavy pressure the oleomargarine oozes out into a receptacle provided, from which it is strained off into barrels for consumption.

The churning process commences by adding to each one hundred pounds of the oil about ten pounds of milk, a little soda and coloring matter. The product of this first churning is allowed to come in contact with ice and is again churned, with a second addition of milk, and, after fifteen minutes' agitation, the solidified oil takes up a certain percentage of the milk, as well as its flavor and odor, and is ready for market. It is of a light, yellow color, pleasant to the taste, and entirely free from any strong or rancid flavor.

Of the desirable fatty elements, artificial butter contains eighty-two per cent., while cream butter has eighty-six. Competent authorities claim that the chemical properties of both are nearly identical; that genuine butter is practically the animal fat, drawn through the cow's udder, while butterine is produced from the finer part of fat, stored in other portions of the animal's system; and, finally, that the artificial butter will keep sweet for a greater length of time than the pure article, and is consequently better adapted for use on long voyages and for export.

In conclusion, if the average consumer prefers to spread his bread with caul fat and beef suet, instead of the aromatic product of succulent grasses and clover blossoms, he commits no crime against society, he does no injustice to the farmer; but one thing the agriculturists do ask, if oleomargarine is such an improvement over cream butter, that every package shall be stamped, honestly and fairly, "artificial butter," and that the frauds now perpetrated upon the public of selling the imitation under the name and guise of genuine butter, be prohibited through legislative action and under heavy penalties for transgressors of the law. Let the public know just what they are buying at time of purchase, and not until the unanimous verdict is in favor of artificial butter need our dairymen convert their milch cows into suet machines.—*American Cultivator.*

THE PHOSPHATES.

No better index of what the plant requires to be furnished it to feed upon can be shown than a chemical analysis of the plantation. The results of such analysis we have given in the two previous articles under this head. Examination of the table given in the April number of the *Farmer*, page 45, shows phosphoric acid to be much more prominent, comparatively, in grains than in other plants. The seeds of plants have been shown to contain a greater proportion of this substance than other portions, as the following table indicates:

Wheat grain contains,	·82	per cent.	phosphoric acid.
Wheat straw "	·23	"	" "
Indian corn "	·55	"	" "
Indian corn stalks contain,	·38	"	" "

This showing points to the reason for the fact, that the application of phosphatic manures to grain fields, after a long season of cropping, greatly improves the yield of grain on about the same growth of straw. The extensive and continued cultivation of grain crops by the use of barn-yard or other nitrogenous manures, lacking in the phosphates, has frequently resulted in the marked decrease of the yield of grain, and accompanying increase in the proportion of straw. One might think that the small percentage of phosphoric acid in plants would not call for it to be supplied by special application. But we should remember that this is perhaps the most lacking of plant food constituents in soils. In addition to this fact, it is most prominent in those crops which are sold from the farm and enter most largely into food consumption. The grains are the great food staples of the world. The potato, which is almost the one vegetable of all American and European peoples, though the percentage of phosphoric acid in it is small, yet in the amount per acre removed by it, it nearly equals the wheat crop. The milk of a good cow is said to contain annually 100 pounds of this plant food ingredient. In the following table is given the amounts of the substances named removed per acre by an average Massachusetts crop:

	Average yield, lbs.	Nitrogen.	Potash.	Phosphoric Acid.
Indian corn.............	1,920	55·31	91·37	30·09
Wheat..................	1,093	29·90	17·15	14·18
Potatoes...............	7,560	24·19	42·80	13·60
Rye....................	1,008	23·38	23·31	12·08
Hay....................	1,920	25·15	32·83	7·87

—*Goessmann.*

That fertilizing substance which is of most practical importance, and it is the most necessary to supply, is not that one which the analysis of the plants shows most prominent; but it is that one, or the several substances which are most lacking in the natural sources of plant food. As before re-

marked, phosphoric acid is perhaps the most lacking in soils generally of any constituent of plant food. Since Liebig, the great father of agricultural chemistry, first called attention to the importance of phosphoric acid in plants, its peculiar effects, and sources, phosphatic manures have been used in enormous quantities. Indeed, this class of manures has been less neglected in many sections than any others; perhaps because as much from the immediate perceptible effects, due to past neglect, than from actual knowledge of facts in the case.

The effect of phosphoric acid in the plant is but little known; its importance is an undisputed fact. Outwardly, in the soil, it was noticed by Messrs. Lawes and Gilbert, many years ago, to have a marked influence on the development of fibrous roots on the turnip. Last year similar effects were independently observed by Dr. Sturtevant, on Waushakum Farm, in the case of the corn plant. This fact probably explains why the application of superphosphates in the hill has a stimulating influence on the young plants. The small fibrous roots are essentially those which take up the soil food of the plant. The practice, therefore, is shown to be a rational one.

Of all the fertilizing substances of importance there is less loss of phosphoric acid in the soil. Potash, in any of its combinations, will leach through the soil to a greater or less extent, and be lost in the drainage waters; likewise with nitrates, and ammonia compounds, which also suffer loss into the air. Phosphoric acid, however, is found in drainage waters in but very small quantities; the particles of an ordinarily retentive soil, having the power to hold it in suspension, so that even a heavy rain has been found to have no apparent effect in washing it down. This fact is established by the analysis of drainage waters, natural waters, etc., as well as by laboratory experiment. In certain experiments of Lawes and Gilbert, after repeated applications of phosphates, phosphoric acid was found only in traces below five inches from the surface. We may conclude from this that there is, practically, no loss of this substance from manures containing it applied to an ordinary retentive soil. —*Scientific Farmer.*

HOW TO MAKE BONE AND HORN MANURE.

Horn is valuable for the nitrogen it contains; pure horn containing from 12 to 15 per cent. Treating with acid is more expensive than necessary for farm practice. A cheap and efficient method is to break or grind the horns fine, and compost with horse manure and unleached ashes: 1 part ashes, 1 part horn, 4 parts dung. Wet this frequently with water, or, better, with urine from the stables. If the heap is found to be heating too rapidly, it should be forked over, then packed down quite solidly. In three to six months' time, according to the fineness of the horn, the horn will be thoroughly decomposed. The heap should be covered with a thin layer of earth or plaster, or both, to absorb the ammonia which will be set free. The same method we also recommend for bones. With the nitrogen and phosphoric acid of the horn and dung, and the potash and phosphoric acid of the ashes, this compost will make a complete manure, good for almost any crop.

Burning the bones would drive off all of the nitrogen, of which there is from 3 to 4 per cent., in pure bones, or $15 to ... worth per ton. Whether one can better afford to lose this nitrogen, or have the bones ground at a mill, each must decide for himself. Unless the bones are ground, it is no use to treat them with sulphuric acid.—*Scientific Farmer.*

VALUATION OF MANURES.

The value of the elements of plant food presented in fertilizers and manurial substances changes from time to time, in accordance with the state of the markets, and hence we find a difference in the valuation from time to time. The chemical analysis of a substance shows its real value as plant food, but the price of crops, as compared with the price of fertilizer, determines the valuation for the farmer. We take the following table of present commercial valuation from the able report of Professor Goessman, the State inspector of commercial fertilizers:

Soluble phosphoric acid, per pound	12·5 cents.
Reduced phosphoric acid, per pound	9·0 "
Insoluble phosphoric acid (of bones), per pound,	6·0 "
Nitrogen (of meat, blood fish, guano, etc.), per pound	21·0 "
Potassium oxide (kainit), per pound	7·5 "

These are average prices for last year, but they may be arranged in a more detailed form, as below, for there is a difference in valuation depending on the source of supply, or more particularly on the availability of these ingredients for plant food. The following table is based on the ruling market prices during the past year in Boston and New York city:

	Price per lb.
I. *Nitrogen*, in form of ammonia and nitric acid	25 cts.
— In form of dried ground meat and blood, finely pulverized steamed bones, finely ground fish guano, Peruvian guano, urates, poudrettes, and artificial guano	20-21 "
— In form of fine ground horn, fine ground bones, wood dust	18 "
— In form of coarsely ground bones, horn shavings and woolen rags, human excretions and barn-yard manure, fish-scraps, animal refuse matter from glue factories and tanneries, etc.	15 "
II. *Phosphoric Acid.* Soluble in water, as contained in alkaline phosphates and superphosphates,	12.5 "
— In Peruvian guano and urates,	9 "
— In form of so called reduced or reverted acid,	9 "
— In precipitated bone phosphate, steamed fine bones, fish guano, according to size and disintegration, from	5-6 "
— In form of boneblack waste, wood-ash, caribbean guano, ground bone ash, coarsely ground bones, poudrette, barn yard manure, etc.	5 "
— In form of finely ground South Carolina and Navassa phosphates	3·5 "
III. *Potassium Oxide*, in form of muriate of potash, or chloride of potassium	6 "
— In form of sulphate of potassa in kainits	7·5 "
— In form of higher grades of sulphate of potassa,	9 "

It is easy for the farmer purchaser, by the use of this table, the guaranteed analysis of the manurial substance being given, to calculate for himself the value. Yet as analyses are given differently, or expressed in different forms in the various States, it may be well to note the proportions of nitrogen, phosphoric acid and potash in the various compounds in which they occur. Thus:

100 parts of ammonia contain 82·35 parts of nitrogen.
" " of nitric acid contain 26 parts of nitrogen.
" " of nitrate soda contain 63·25 parts of nitric acid.
" " of sulphate of potash contain 54·9 parts actual potash.
" " of sulphate of lime (gypsum) contain 32·5 parts of lime.
" " of bone phosphate contain 46 parts phosphoric acid
" " of muriate of potassium contain 63·1 parts of actual potash.
" " of carbonate of lime contain 56 parts of lime.

—*Scientific Farmer.*

Clearing House Plants of Insects.—The following extract from a communication to the London *Garden* gives a useful hint concerning the washing of parlor or greenhouse plants to rid them of insects: "Once a week I put some soft soap and flowers of sulphur into four gallons of soap suds, mixing all well together. The next process is to turn the plants heels upwards and immerse their heads in the soapy solution; but before doing this I prepare a circular piece of stiff card with a hole one half inch in diameter, and a slit reaching from the central opening to the circumference of the card. This is then stretched so as to allow the stem of the plant to be surrounded, and by pressing the fingers of the left hand firmly against it and to the rim of the pot when the plant is turned upside down, no soil can fall into the mixture. By gently moving the head of the plant backwards and forwards in the solution, the leaves become cleansed of insects, and as a kind of soapy gloss clings to the leaves after they are dry, insects do not quickly infest them again."

PAINTED TAPESTRY.

WOVEN TAPESTRY.

DESIGNED FOR THE CITY HALL OF LYONS, BY M. A. DENNELLE, PARIS.—(*From the Workshop.*)

SUGAR FROM CORN.

A factory is in operation at Davenport, Iowa, for the making of sugar from corn, the first in this country. This sugar is the same as maple sugar, or is chemically known as glucose—pure maple sugar, grape sugar, and glucose being one and the same thing. The demand for the article by confectioners alone in the United States is immense. The sources of supply heretofore have been France and Germany, where glucose is made from potatoes. Here it is the product of corn wholly. It is as pleasing to the taste as honey. The production of grape sugar and glucose opens a new department for Iowa corn. The capacity of the works at Davenport is 500 bushels per day. This branch of manufacture bids fair to become of immense importance to the State and country.

It is estimated that an annual gain of $60,000,000 would be made by our farmers if they were more particular to exterminate the weeds from their plowed lands.